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CHEMISTRY MUSING

Chemistry Musing was started from August '13 issue of Chemistry Today with the suggestion of Shri Mahabir Singh. The aim of Chemistry Musing is to augment the chances of bright students preparing for JEE (Main and Advanced) / AIPMT / AIIMS / Other PMTs & PETs with additional study material.

In every issue of Chemistry Today, 10 challenging problems are proposed in various topics of JEE (Main and Advanced) / AIPMT. The detailed solutions of these problems will be published in next issue of Chemistry Today.

The readers who have solved five or more problems may send their solutions. The names of those who send atleast five correct solutions will be published in the next issue.

We hope that our readers will enrich their problem solving skills through "Chemistry Musing" and stand in better stead while facing the competitive exams.

PROBLEM Set 19

JEE MAIN/PMTs

1. Which of the following statements is/are correct?

(I) All oxoacids of chlorine undergo disproportionation on heating.

(II) ClO_2 does not dimerize but Cl_2O_4 exists.

(III) Six Cl—O bonds in Cl_2O_7 are the same.

(IV) $Rb[ICl_2]$ on heating produces RbI + Cl_2.

(a) II and III (b) II, III and IV

(c) I, II and III (d) III only

2. There are three samples of H_2O_2 labelled as 10 vol.; 15 vol.; 20 vol. Half litre of each sample are mixed and then diluted with equal volume of water. Calculate volume strength of the resultant solution.

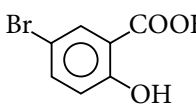
(a) 1.339 (b) 2.68

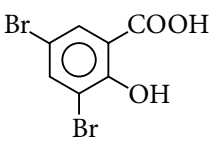
(c) 5.0 (d) 7.5

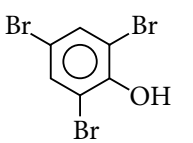
3. At 300 K, the vapour pressure of an ideal solution containing one mole of *A* and three moles of *B* is 550 mm of Hg. At the same temperature, if one mole of *B* is added to this solution, the vapour pressure of solution increases by 10 mm of Hg. The vapour pressures of *A* and *B* in their pure state are (in mm of Hg)

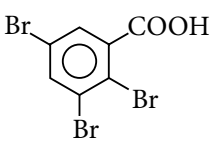
	p_A°	p_B°
(a)	560	600
(b)	600	550
(c)	400	600
(d)	600	400

4. The action of Br_2/H_2O on salicylic acid results in the formation of

(a) 

(b) 

(c) 

(d) 

5. Some statements regarding maleic acid and fumaric acid are given below :

(I) pK_{a_1} of maleic acid is greater than pK_{a_1} of fumaric acid.

(II) Both maleic acid and its first conjugate base have intramolecular hydrogen bonding.

(III) Fumaric acid cannot form hydrogen bonds.

(IV) K_{a_2} of fumaric acid is less than that of maleic acid.

The incorrect statement(s) is/are

(a) II and IV (b) I, III and IV

(c) II only (d) all of these.

JEE ADVANCED

6. Which of the following statements is correct for the two molecules, C_6H_6 and $B_3N_3H_6$?

(a) C—H bond length is identical with N—H and B—H bond lengths.

(b) The nature of double bond is perfectly identical in both.

(c) Both the molecules are planar.

(d) Benzene is more reactive than borazine.

COMPREHENSION

The gas which strictly follows the general gas equation, $PV = nRT$ is called ideal or perfect gas. Actually no gas is ideal or perfect in nature. Thus, van der Waals applied two corrections :

He suggested that the pressure exerted by an ideal gas, P_{ideal} is related to the experimentally measured pressure, P_{real} by the equation :

$$P_{ideal} = P_{real} + \frac{a}{V^2} \quad \text{(for 1 mole of a gas)}$$

(P_{real} ↑ Observed pressure; $\frac{a}{V^2}$ ↑ Correction term)

Another correction concerns the volume occupied by the gas molecules. In the ideal gas equation, V represents the volume of the container. However, each molecule does occupy a finite, although small, intrinsic volume, so the effective volume of the gas becomes $(V - b)$ for 1 mole of a gas.

Having taken into account the corrections for pressure and volume, the general gas equation for one mole of the gas may be written as :

$$\left(P + \frac{a}{V^2}\right)(V - b) = RT$$

($P + \frac{a}{V^2}$ ↑ Corrected pressure; $V - b$ ↑ Corrected volume)

7. The van der Waals' constant 'a' for CO_2 gas is greater than that of H_2 gas. It means that the

(a) strength of van der Waals forces of CO_2 gas is less than that of H_2 gas

(b) strength of van der Waals forces of CO_2 gas is equal to that of H_2 gas

(c) CO_2 gas can be more easily liquified

(d) H_2 gas can be more easily liquified.

8. Using van der Waals' equation, find the constant 'a' (in atm L^2 mol^{-2}) when three moles of a gas confined in a 6 L flask exerts a pressure of 13.0 atm at a temperature of 373 K. The value of 'b' is 0.05 L mol^{-1}.

($R = 0.082$ L atm K^{-1} mol^{-1})

(a) 10.47 (b) 9.39

(c) 6.46 (d) 10.74

INTEGER VALUE

9. The value of x in the following reaction is

$$Cl{-}\overset{\overset{O}{\|}}{C}{-}OC_2H_5 \xrightarrow[(ii)\ H_2O/H^+]{(i)\ x \text{ moles of } RMgX} \text{An alcohol}$$

10. Starting with an initial pressure of 5 atm of azoisopropane, 40% of it decomposes into nitrogen and hexane vapours in one hour. The pressure (in atm) exerted by the mixture at this time will be

Solution Senders of Chemistry Musing

SET 18

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SET 17

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VERI- SIMILAR
PRACTICE PAPER 2015

Exam on 3rd May

AIPMT Special

1. Reaction of *t*-butyl bromide with sodium methoxide produces
(a) isobutane
(b) isobutylene
(c) sodium *t*-butoxide
(d) *t*-butyl methyl ether.

2. The ions O^{2-}, F^-, Na^+, Mg^{2+} and Al^{3+} are isoelectronic. Their ionic radii show
(a) a significant increase from O^{2-} to Al^{3+}
(b) a significant decrease from O^{2-} to Al^{3+}
(c) an increase from O^{2-} to F^- and then decrease from Na^+ to Al^{3+}
(d) a decrease from O^{2-} to F^- and then increase from Na^+ to Al^{3+}.

3. Identify *A* in the following sequence of reactions :

$$A \xrightarrow[1\text{ mole}]{NH_3} B \xrightarrow[\text{Alc. KOH}]{CHCl_3} C \xrightarrow{\text{Red}^n} (CH_3)_2CHNHCH_3$$

(a) Ethyl halide (b) *iso*-Propylamine
(c) *n*-Propyl halide (d) *iso*-Propyl halide

4. Under what conditions of temperature and pressure, the formation of atomic hydrogen from molecular hydrogen will be favoured the most?
(a) High temperature and high pressure
(b) Low temperature and low pressure
(c) High temperature and low pressure
(d) Low temperature and high pressure

5. For an isomerization reaction $A \rightleftharpoons B$, the temperature dependence of equilibrium constant is given by

$$\log K = 4 - \frac{2000}{T}$$

The value of $\Delta S°$ at 300 K is
(a) 4 *R* (b) 5 *R*
(c) 400 *R* (d) 2000 *R*

6. In the given reaction,

$$C_7H_8 \xrightarrow{3Cl_2/\Delta} A \xrightarrow{Br_2/Fe} B \xrightarrow{Zn/HCl} C$$

the product *C* is
(a) *o*-bromotoluene
(b) *m*-bromotoluene
(c) *p*-bromotoluene
(d) 3-bromo-2, 4, 6-trichlorotoluene.

7. The experimental data for the reaction, $A + B \rightarrow C$ is given below :

Experiment	[*A*] (M)	[*B*] (M)	Initial rate (mol L^{-1} s^{-1})
1	0.50	0.50	1.6×10^{-4}
2	0.50	1.00	3.2×10^{-4}
3	1.00	1.00	3.2×10^{-4}

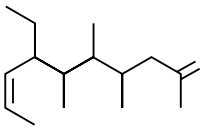
The rate equation for the above reaction is
(a) rate = $k[B]$ (b) rate = $k[B]^2$
(c) rate = $k[A]^2[B]^2$ (d) rate = $k[A]^2[B]$

8. Which of the following sets of quantum numbers is not possible ?

	n	*l*	m_l	m_s
(a)	3	2	–1	–1/2
(b)	2	2	–2	+1/2
(c)	1	0	0	–1/2
(d)	2	0	0	+1/2

9. The ability of anion to bring about coagulation of a given colloid, depends upon
(a) magnitude of the charge
(b) both magnitude and charge
(c) its charge only
(d) sign of the charge alone.

10. The IUPAC name of the compound



is

(a) 4-ethyl-5, 6, 7, 9-tetramethyldeca-2, 9-diene
(b) 7-ethyl-2, 4, 5, 6-tetramethyldeca-1, 8-diene
(c) 7-ethyl-2, 4, 5, 6-tetramethyldeca-1, 7-diene
(d) 7-(1-propenyl)-2, 3, 4, 5-tetramethylnon-1-ene.

11. The value of the reaction quotient '*Q*' for the cell,
$Zn_{(s)} \mid Zn^{2+}_{(aq)}$ (0.01 M) $\| Ag^{+}_{(aq)}$ (1.25 M) $\mid Ag_{(s)}$ is
(a) 156 (b) 125
(c) 1.25×10^{-2} (d) 6.4×10^{-3}

12. What is *Z* in the following sequence of reactions?

$$\text{Phenol} \xrightarrow[\text{dust}]{\text{Zn}} X \xrightarrow[\text{anhyd. } AlCl_3]{CH_3Cl} Y \xrightarrow{KMnO_{4(alk.)}} Z$$

(a) Benzene (b) Toluene
(c) Benzaldehyde (d) Benzoic acid

13. The position of both, an electron and a helium atom is known within 1.0 nm. Further the momentum of the electron is known within 5.0×10^{-26} kg ms^{-1}. The minimum uncertainty in the measurement of the momentum of the helium atom is
(a) 8.0×10^{-26} kg ms^{-1}
(b) 80 kg ms^{-1}
(c) 50 kg ms^{-1}
(d) 5.0×10^{-26} kg ms^{-1}

14. In the reaction,

$$\text{Phenol} \xrightarrow{NaOH} A \xrightarrow[140^\circ C]{CO_2 + HCl} B$$

B is
(a) benzaldehyde (b) chlorobenzene
(c) benzoic acid (d) salicylic acid.

15. A compound contains 38.8% C, 16.0% H and 45.2% N. The formula of the compound would be
(a) CH_3NH_2 (b) CH_3CN
(c) C_2H_5CN (d) $CH_2(NH_2)_2$

16. The unsaturated hydrocarbon C_6H_{10} which produces $OHC(CH_2)_4CHO$ on ozonolysis is
(a) hex-1-yne
(b) hex-2,4-diene
(c) cyclohexene
(d) 1-methylcyclopentene.

17. 10 g of glucose (π_1), 10 g of urea (π_2) and 10 g of sucrose (π_3) are dissolved in 250 mL of water at 300 K. The relationship between the osmotic pressures of the solutions is
(a) $\pi_1 > \pi_2 > \pi_3$ (b) $\pi_3 > \pi_1 > \pi_2$
(c) $\pi_2 > \pi_1 > \pi_3$ (d) $\pi_2 > \pi_3 > \pi_1$

18. $XeOF_4$ contains
(a) six electron pairs forming an octahedron with two positions occupied by lone pairs
(b) two π-bonds and the remaining six electron pairs forming an octahedron
(c) three π-bonds and the remaining four electron pairs forming a tetrahedron
(d) one π-bond and the remaining six electron pairs forming an octahedron with one position occupied by a lone pair.

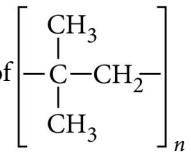
19. The correct set of oxidation numbers of nitrogen in ammonium nitrate is
(a) –3, +3 (b) –1, +1
(c) +1, –1 (d) –3, +5

20. In a reaction if the initial concentration of the reactant is increased four times then the rate becomes eight times of its initial value. The order of the reaction is
(a) 2.0 (b) 3.5
(c) 2.5 (d) 1.5

21. The root mean square speed of molecules of N_2 gas is *u*. If the temperature is doubled and the nitrogen molecules dissociate into nitrogen atoms, the root mean square speed becomes
(a) $u/2$ (b) $2u$
(c) $4u$ (d) $14u$

22. Equal amounts of a solute are dissolved in equal amounts of two solvents *A* and *B*. The lowering of vapour pressure for the solution *A* is twice the lowering of vapour pressure for the solution *B*. If M_A and M_B are the molecular weights of solvents *A* and *B* respectively, then
(a) $M_A = M_B$ (b) $M_A = M_B/2$
(c) $M_A = 4M_B$ (d) $M_A = 2M_B$

23. The maximum pH of a solution which is 0.1 M in Mg^{2+} from which $Mg(OH)_2$ is not precipitated is
(Given : K_{sp} for $Mg(OH)_2 = 1.2 \times 10^{-11}$)
(a) 4.96 (b) 6.96
(c) 7.54 (d) 9.04

24. Monomer of  is
(a) 2-methylpropene (b) styrene
(c) propylene (d) ethene.

25. A complex of a certain metal ion has a magnetic moment of 4.90 B.M. Another complex of the same metal ion in the same oxidation state has a zero magnetic moment. Which of the following could be the central metal ion in the two complexes?
(a) Mn^{2+} (b) Fe^{3+}
(c) Fe^{2+} (d) Cr^{3+}

26. The metal that dissolves in liquid ammonia, giving a dark blue coloured solution is
(a) tin (b) lead
(c) sodium (d) silver.

27. An organic compound '*A*' having molecular formula $C_5H_{10}Cl_2$ is hydrolysed to compound '*B*' ($C_5H_{10}O$) which gives an oxime with hydroxylamine and yellow precipitate with a mixture of iodine and sodium hydroxide. The compound '*A*' should be
(a) $CH_3CH_2CCl_2CH_2CH_3$
(b) $CH_3CH_2CH_2CCl_2CH_3$
(c) $CH_3CH_2CH_2CH_2CHCl_2$
(d) $CH_3CH_2CH_2CHClCH_2Cl$

28. Gas '*X*' can be easily liquified in comparison to gas '*Y*'. This indicates
(a) strength of van der Waals' forces for '*X*' is less than that of '*Y*'
(b) strength of van der Waals' forces for both '*X*' and '*Y*' is same
(c) the value of van der Waals' constant '*a*' for gas '*X*' is greater than that for gas '*Y*'
(d) the value of van der Waals' constant '*a*' for gas '*X*' is less than that for gas '*Y*'.

29. Which of the following will not show geometrical isomerism?
(a) $[Cr(NH_3)_4Cl_2]Cl$ (b) $[Co(en)_2Cl_2]Cl$
(c) $[Co(NH_3)_5NO_2]Cl_2$ (d) $[Pt(NH_3)_2Cl_2]$

30. Consider the following compounds :
(i) sulphur dioxide
(ii) hydrogen peroxide
(iii) ozone
Among these compounds identify those that can act as bleaching agent
(a) i and iii (b) ii and iii
(c) i and ii (d) i, ii and iii

31. In the following reaction,

$$X \xrightarrow{Br_2/H_2O} Y \xrightarrow[0\text{-}5°C]{NaNO_2/HCl} Z \xrightarrow[C_2H_5OH]{\text{Boiling}} \text{Tribromobenzene}$$

X is
(a) benzoic acid (b) salicyclic acid
(c) phenol (d) aniline.

32. Which of the following reactions will not occur?
(a) $Fe + H_2SO_4 \longrightarrow FeSO_4 + H_2$
(b) $Cu + 2AgNO_3 \longrightarrow Cu(NO_3)_2 + 2Ag$
(c) $2KBr + I_2 \longrightarrow 2KI + Br_2$
(d) $CuO + H_2 \longrightarrow Cu + H_2O$

33. Which one of the following orders is incorrect, with respect to the property indicated?
(a) Benzoic acid > phenol > cyclohexanol (acid strength)
(b) Aniline > cyclohexylamine > benzamide (basic strength)
(c) Formic acid > acetic acid > propanoic acid (acid strength)
(d) Fluoroacetic acid > chloroacetic acid > bromoacetic acid (acid strength)

34. Three elements *A*, *B* and *C* crystallize into a cubic solid lattice. Atoms *A* occupy the corners, atoms *B* the cube centres and atoms *C* the edges. The formula of the compound is
(a) *ABC* (b) ABC_2
(c) ABC_3 (d) ABC_4

35. The following equilibrium constants are given :

$$N_2 + 3H_2 \rightleftharpoons 2NH_3 ; K_1$$
$$N_2 + O_2 \rightleftharpoons 2NO ; K_2$$
$$H_2 + 1/2\ O_2 \rightleftharpoons H_2O ; K_3$$

The equilibrium constant for the oxidation of NH_3 by oxygen to give NO is

(a) $\frac{K_2K_3^2}{K_1}$ (b) $\frac{K_2^2K_3}{K_1}$

(c) $\frac{K_1K_2}{K_3}$ (d) $\frac{K_2K_3^3}{K_1}$

36. When 3 moles of the reactant *A* and 1 mole of the reactant *B* are mixed in a vessel of volume 1 L, the following reaction takes place,
$A_{(g)} + B_{(g)} \rightleftharpoons 2C_{(g)}$.
If 1.5 moles of *C* is formed at equilibrium, the equilibrium constant (K_c) for the reaction is
(a) 0.12 (b) 0.50
(c) 0.25 (d) 4.00

37. The correct order of the increasing ionic character is
(a) $BeCl_2 < BaCl_2 < MgCl_2 < CaCl_2$
(b) $BeCl_2 < MgCl_2 < BaCl_2 < CaCl_2$
(c) $BeCl_2 < MgCl_2 < CaCl_2 < BaCl_2$
(d) $BaCl_2 < CaCl_2 < MgCl_2 < BeCl_2$

38. Starting with three different amino acid molecules how many different tripeptide molecules could be formed?
(a) 9 (b) 12
(c) 6 (d) 3

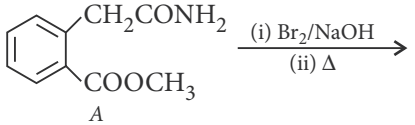
39. Uncertainty in position of an electron (mass = 9.1×10^{-28} g) moving with a velocity of 3×10^4 cm/s accurate upto 0.001% will be ($h = 6.626 \times 10^{-27}$ erg-second)
(a) 5.76 cm (b) 7.68 cm
(c) 1.93 cm (d) 3.84 cm

40. At room temperature sodium crystallises in a body centred cubic lattice with edge length 4.24 Å. The density of sodium will be
(a) 2.0 g cm^{-3} (b) 1.0 g cm^{-3}
(c) 23.0 g cm^{-3} (d) 4.0 g cm^{-3}

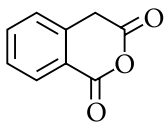
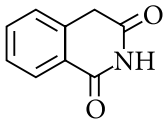
41. While extracting an element from its ore, the ore is ground and leached with dilute solution of sodium cyanide to form the soluble product. The element is
(a) lead (b) chromium
(c) manganese (d) silver.

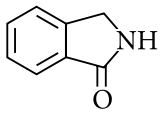
42. Number of molecules in one litre of water is close to (assuming density of water = 1 g cm^{-3})
(a) $\frac{18}{22.4} \times 10^{23}$ (b) $55.5 \times 6.023 \times 10^{23}$
(c) $\frac{6.023}{23.4} \times 10^{23}$ (d) $18 \times 6.023 \times 10^{23}$

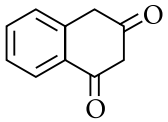
43. The following sequence of reactions on *A* gives



A

(a) 
(b) 

(c) 

(d) 

44. Which of the following hydrides of group 16 elements has lowest thermal stability and maximum acid strength?
(a) H_2S (b) H_2O
(c) H_2Se (d) H_2Te

45. In which of the following pairs, there is greatest difference in the oxidation numbers of the underlined elements?
(a) $\underline{N}O_2$ and $\underline{N}_2O_4$ (b) $\underline{P}_2O_5$ and $\underline{P}_4O_{10}$
(c) $\underline{N}_2O$ and $\underline{N}O$ (d) $\underline{S}O_2$ and $\underline{S}O_3$

SOLUTIONS

1. (b): $CH_3-\underset{\underset{CH_3}{|}}{\overset{CH_3}{\overset{|}{C}}}-Br + \overset{+}{Na}\overset{\cdot\cdot}{\underset{\cdot\cdot}{O}}-CH_3 \longrightarrow$
Sod. methoxide

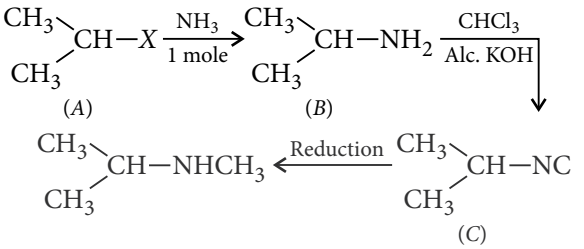
tert-Butyl bromide

$CH_3-\underset{CH_3}{\overset{|}{C}}=CH_2 + NaBr + CH_3OH$

2-Methylpropene
(Isobutylene)

2. (b): Amongst isoelectronic ions, ionic radii of anions is more than that of cations. Further, size of the anion increases with increase in –ve charge and size of cation decreases with increase in +ve charge. Hence, the correct order of ionic radii is
$O^{2-} > F^- > Na^+ > Mg^{2+} > Al^{3+}$.

3. (d):



4. (c): $H_{2(g)} \longrightarrow H_{(g)} + H_{(g)}$; ΔH = +ve

According to Le-Chatelier's principle, the forward reaction is favoured by lowering pressure (as number of gaseous moles are increasing) and by increasing temperature as it is endothermic.

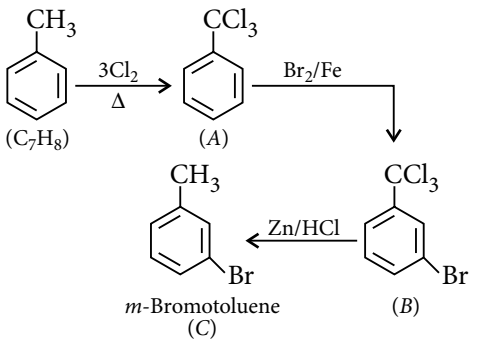
5. (a): Variation of K with temperature is given by

$$\log K = \frac{\Delta S^\circ}{R} - \frac{\Delta H^\circ}{2.303RT}$$

$$\log K = 4 - \frac{2000}{T} \text{ (given)}$$

$$\therefore \quad \frac{\Delta S^\circ}{R} = 4 \Rightarrow \Delta S^\circ = 4\,R$$

6. (b):



7. (a): Rate = $k[A]^x[B]^y$

From exp. 1 and 2, we get

$$\frac{1.6\times10^{-4}}{3.2\times10^{-4}} = \frac{k(0.50)^x(0.50)^y}{k(0.50)^x(1.00)^y} = \left(\frac{1}{2}\right)^y \Rightarrow \quad y = 1$$

From exp. 2 and 3, we get

$$\frac{3.2\times10^{-4}}{3.2\times10^{-4}} = \frac{k(0.50)^x(1.00)^y}{k(1.00)^x(1.00)^y}$$

$$1 = \left(\frac{1}{2}\right)^x \Rightarrow \left(\frac{1}{2}\right)^0 = \left(\frac{1}{2}\right)^x \Rightarrow x = 0$$

Hence, rate equation will be

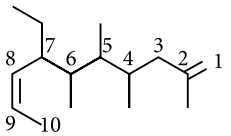
rate = $k[A]^0[B]^1$

rate = $k[B]$

8. (b)

9. (b): Both magnitude and nature of charge affect coagulation of a given colloid. Greater the magnitude of the –ve charge, quicker will be the coagulation of +vely charged colloid.

10. (b):



7-Ethyl-2, 4, 5, 6-tetramethyldeca-1, 8-diene

11. (d): The cell reaction is

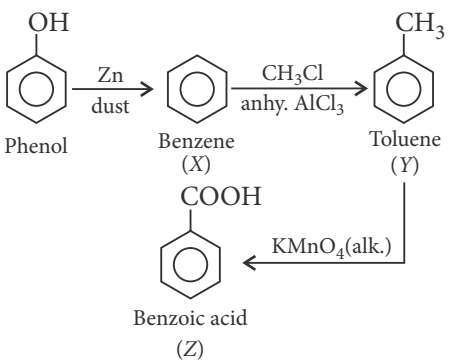
$$Zn_{(s)} \longrightarrow Zn^{2+}_{(aq)}\,(0.01\text{ M}) + 2e^-$$

$$[Ag^+_{(aq)}(1.25\text{ M}) + e^- \longrightarrow Ag_{(s)}] \times 2$$

$$Zn_{(s)} + 2Ag^+_{(aq)}\,(1.25\,\text{M}) \longrightarrow Zn^{2+}_{(aq)}(0.01\,\text{M}) + 2Ag_{(s)}$$

$$Q = \frac{[Zn^{2+}]}{[Ag^+]^2} = \frac{0.01}{(1.25)^2} = 6.4\times10^{-3}$$

12. (d):



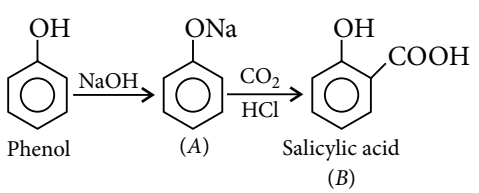
13. (d): According to uncertainty principle,

$$\Delta x \times \Delta p = \frac{h}{4\pi}$$

As, Δx =1.0 nm for both electron and helium atom, so Δp is also same for both the particles.

Thus, uncertainty in momentum of the helium atom is also 5.0×10^{-26} kg ms^{-1}.

14. (d):

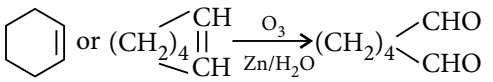


15. (a) :

Element	%	At. wt.	Molar ratio	Simplest ratio
C	38.8	12	3.23	1
H	16.0	1	16.0	5
N	45.2	14	3.23	1

Empirical formula = CH_5N or CH_3NH_2

16. (c) : Since the unsaturated hydrocarbon on ozonolysis gives a single compound, having two aldehydic groups, it must be cyclic.



Cyclohexene

17. (c) : $\pi = \frac{nRT}{V}, \pi = \frac{wRT}{MV}$

$\therefore \quad \pi \propto \frac{1}{M}$

Mol. wts of glucose, urea and sucrose is in the order : sucrose > glucose > urea

Hence, the order of their osmotic pressures is urea > glucose > sucrose *i.e.*, $\pi_2 > \pi_1 > \pi_3$

18. (d)

19. (d): $\overset{x}{[NH_4]}^+ \overset{y}{[NO_3]}^-$

$x + 4 = +1 \Rightarrow x = -3; y - 6 = -1 \Rightarrow y = +5$

20. (d): Rate $= k[A]^n$ or $r = k[A]^n$ ...(i)

$8r = k(4[A])^n$ ...(ii)

Dividing eqn (ii) by (i), we get

$2^3 = 2^{2n}$ or $2n = 3 \Rightarrow n = 1.5$

21. (b): $(u_{rms})_1 = \sqrt{\frac{3RT_1}{M_1}}$,

for N_2 molecule, $M_1 = 28$.

$(u_{rms})_2 = \sqrt{\frac{3RT_2}{M_2}}$, for N atom, $M_2 = 14$.

$$\frac{(u_{rms})_1}{(u_{rms})_2} = \frac{\sqrt{\frac{3RT_1}{M_1}}}{\sqrt{\frac{3RT_2}{M_2}}} = \sqrt{\frac{3RT_1}{M_1} \times \frac{M_2}{3RT_2}}$$

$$= \sqrt{\frac{T_1 \times 14}{28 \times 2T_1}} = \sqrt{\frac{1}{4}} = \frac{1}{2}$$

$(u_{rms})_2 = 2(u_{rms})_1 = 2\ u$

22. (d): $\left(\frac{p^\circ - p}{p^\circ}\right)_A = x_A = \frac{n}{n_A}$ ...(i)

$\left(\frac{p^\circ - p}{p^\circ}\right)_B = x_B = \frac{n}{n_B}$ ...(ii)

By dividing eqn (i) by (ii), we get

$$\frac{\left(\frac{p^\circ - p}{p^\circ}\right)_A}{\left(\frac{p^\circ - p}{p^\circ}\right)_B} = \frac{n_B}{n_A} = \frac{w}{M_B} \times \frac{M_A}{w} = \frac{M_A}{M_B}$$

$$2 = \frac{M_A}{M_B} \Rightarrow M_A = 2M_B$$

23. (d): $Mg(OH)_2 \rightleftharpoons Mg^{2+} + 2OH^-$,

$K_{sp} = [Mg^{2+}][OH^-]^2$

$1.2 \times 10^{-11} = 0.1 \times [OH^-]^2$

$[OH^-]^2 = 1.2 \times 10^{-10} \Rightarrow [OH^-] = 1.1 \times 10^{-5}$

$[H^+] = 10^{-14}/(1.1 \times 10^{-5}) = 9.09 \times 10^{-10}$ M

$pH = -\log [H^+] = -\log (9.09 \times 10^{-10})$

$= 10 - 0.9586 = 9.04$

24. (a)

25. (c) : Since the magnetic moment of the one complex is 4.90 B.M. so the metal ion contains 4 unpaired electrons.

Since another complex of the same metal ion in the same oxidation state shows zero magnetic moment, so in this complex there is no unpaired electron. This is possible in d^6 configuration.

Mn (25) : $3d^5 4s^2$; Mn^{2+}: $3d^5$

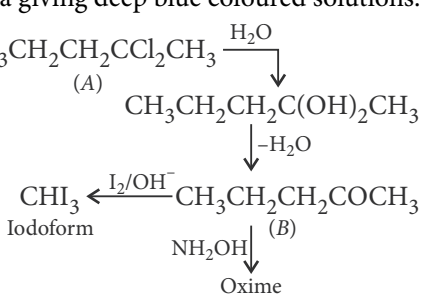
Fe (26) : $3d^6 4s^2$; Fe^{3+}: $3d^5$

Fe (26) : $3d^6 4s^2$; Fe^{2+}: $3d^6$

Cr (24) : $3d^5 4s^1$; Cr^{3+}: $3d^3$

26. (c) : All the alkali metals dissolve in liquid ammonia giving deep blue coloured solutions.

27. (b):

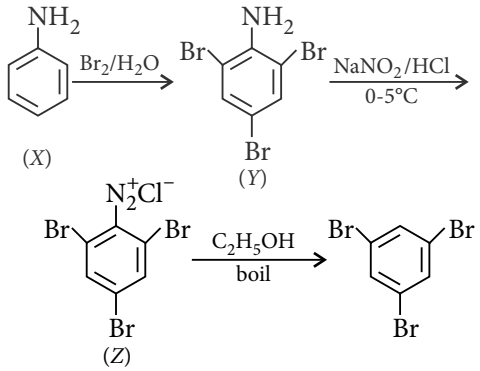


28. (c)

29. (c) : Octahedral complexes of the type MA_5B do not show any geometrical isomerism.

30. (d)

31. (d):



32. (c) : I_2 is weaker oxidising agent than Br_2 therefore, it is unable to displace bromine.

33. (b): Basic strength decreases as,
cyclohexylamine > aniline > benzamide.
Lesser basicity of aniline and benzamide is due to participation of lone pair of electrons of $-NH_2$ group in resonance.
Amides are much less basic than amines.

34. (c) : No. of A atoms per unit cell $= 8 \times \frac{1}{8} = 1$

No. of B atoms per unit cell = 1

No. of C atoms per unit cell $= 12 \times \frac{1}{4} = 3$

Ratio $A : B : C = 1 : 1 : 3$.
Hence, the formula is ABC_3.

35. (d): $N_2 + 3H_2 \rightleftharpoons 2NH_3$;

$$K_1 = \frac{[NH_3]^2}{[N_2][H_2]^3} \quad \ldots(i)$$

$N_2 + O_2 \rightleftharpoons 2NO$; $K_2 = \frac{[NO]^2}{[N_2][O_2]}$ …(ii)

$H_2 + \frac{1}{2}O_2 \rightleftharpoons H_2O$; $K_3 = \frac{[H_2O]}{[H_2][O_2]^{1/2}}$ …(iii)

For the reaction, $2NH_3 + \frac{5}{2}O_2 \rightleftharpoons 2NO + 3H_2O$;

$$K = \frac{[NO]^2[H_2O]^3}{[NH_3]^2[O_2]^{5/2}}$$

$$= \frac{[NO]^2}{[N_2][O_2]} \times \frac{[H_2O]^3}{[H_2]^3[O_2]^{3/2}} \times \frac{[N_2][H_2]^3}{[NH_3]^2}$$

$$= \frac{K_2 \times K_3^3}{K_1}$$

36. (d):

	$A_{(g)}$	+ $B_{(g)}$	$\rightleftharpoons$	$2C_{(g)}$
Initial moles	3	1		0
Moles at eqm	3–x	1–x		$2x$

Given that $2x = 1.5 \Rightarrow x = 1.5/2$

$$K_c = \frac{[C]^2}{[A][B]} = \frac{(2x)^2}{(3-x)(1-x)}$$

($\because$ volume of vessel = 1 L)

$$K_c = \frac{4x^2}{(3-x)(1-x)}$$

$$K_c = \frac{(1.5)^2}{2.25 \times 0.25} = \frac{100}{25} = 4$$

37. (c) **38. (c)**

39. (c) : Mass of an electron (m) = 9.1×10^{-28} g;
Velocity of electron (v) = 3×10^4 cm/s;
Accuracy = 0.001% = $\frac{0.001}{100}$ and Planck's constant (h) = 6.626×10^{-27} erg-second.
We know that actual velocity of the electron (Δv)

$$= 3 \times 10^4 \times \frac{0.001}{100} = 0.3 \text{ cm/s}$$

Therefore, uncertainty in the position of the electron $(\Delta x) = \frac{h}{4\pi m \Delta v}$

$$= \frac{6.626 \times 10^{-27}}{4\pi \times (9.1 \times 10^{-28}) \times 0.3} = 1.93 \text{ cm}$$

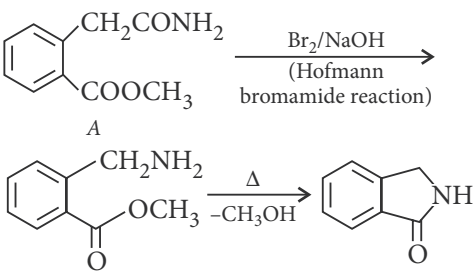
40. (b) **41. (d)**

42. (b): 1 litre of H_2O weighs = 1000 g

$$= \frac{1000}{18} = 55.55 \text{ moles}$$

$\therefore$ No. of molecules in 1 L of H_2O
$= 55.55 \times 6.023 \times 10^{23}$

43. (c) :



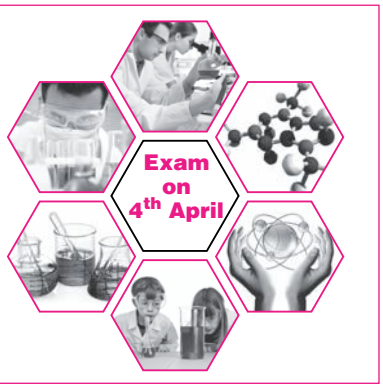
44. (d): H_2O, H_2S, H_2Se, H_2Te

Thermal stability decreases
Acidic strength increases

45. (d)

Practice Paper 2015

JEE MAIN



1. A cylinder of compressed gas that bears no label is supposed to contain either ethylene or propylene. Combustion of the sample shows that 12 cm^3 of the gas requires 54 cm^3 of oxygen for complete combustion. This indicates that the gas is

(a) only ethylene
(b) only propylene
(c) 1 : 1 mixture of the two gases
(d) some unknown mixture of the two gases.

2. E°_{red} of different half-cells are given :

$E^\circ_{Cu^{2+}/Cu} = 0.34$ V; $E^\circ_{Zn^{2+}/Zn} = -0.76$ V;

$E^\circ_{Ag^+/Ag} = 0.80$ V; $E^\circ_{Mg^{2+}/Mg} = -2.37$ V

In which cell is ΔG° most negative?

(a) $Zn \mid Zn^{2+}$ (1 M) $\mid\mid Mg^{2+}$ (1 M) $\mid Mg$
(b) $Zn \mid Zn^{2+}$ (1 M) $\mid\mid Ag^{+}$ (1 M) $\mid Ag$
(c) $Cu \mid Cu^{2+}$ (1 M) $\mid\mid Ag^{+}$ (1 M) $\mid Ag$
(d) $Ag \mid Ag^{+}$ (1 M) $\mid\mid Mg^{2+}$ (1 M) $\mid Mg$

3. On the basis of given reduction potential data,

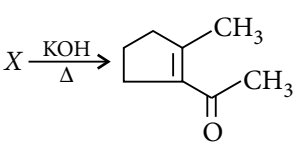
$E^\circ_{Fe^{2+}/Fe} = -0.44$ V, $E^\circ_{Cu^{2+}/Cu} = 0.34$ V,

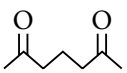
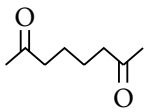
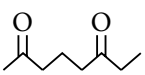
$E^\circ_{Ag^+/Ag} = 0.80$ V

which of the following statements is correct?

(a) Cu displaces Fe from $FeSO_4$ solution
(b) Ag displaces Cu from $CuSO_4$ solution
(c) Fe displaces Cu from $CuSO_4$ solution
(d) None of these

4. Identify '*X*' in the following reaction,



(a) 
(b) 
(c) 
(d) None of these

5. The factor of ΔG values is important in metallurgy. The ΔG values for the following reactions at 800°C are given as :

$S_{2(g)} + 2O_{2(g)} \longrightarrow 2SO_{2(g)}$; $\Delta G = -544$ kJ

$2Zn_{(s)} + S_{2(g)} \longrightarrow 2ZnS_{(s)}$; $\Delta G = -293$ kJ

$2Zn_{(s)} + O_{2(g)} \longrightarrow 2ZnO_{(s)}$; $\Delta G = -480$ kJ

The ΔG for the reaction,

$2ZnS_{(s)} + 3O_{2(g)} \longrightarrow 2ZnO_{(s)} + 2SO_{2(g)}$ will be

(a) –731 kJ (b) –773 kJ
(c) –229 kJ (d) –357 kJ

6. Iron exhibits +2 and +3 oxidation states. Which of the following statements about iron is incorrect?

(a) Ferrous oxide is more basic in nature than the ferric oxide.
(b) Ferrous compounds are relatively more ionic than the corresponding ferric compounds.
(c) Ferrous compounds are less volatile than the corresponding ferric compounds.
(d) Ferrous compounds are more easily hydrolysed than the corresponding ferric compounds.

7. Among LiCl, RbCl, $BeCl_2$, $MgCl_2$, the compounds with most and least ionic character respectively are

(a) LiCl and RbCl (b) RbCl and $BeCl_2$
(c) RbCl and $MgCl_2$ (d) $MgCl_2$ and $BeCl_2$

8. The density of an ionic compound (mol. wt. 58.5) is 2.165 g cm^{-3} and the edge length of unit cell is 562 pm, then the closest distance between $A^+—B^-$ and rank of unit cell is

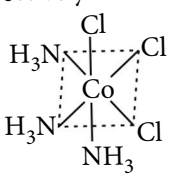
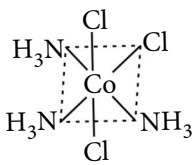
(a) 281 pm, 4 (b) 562 pm, 2
(c) 562 pm, 4 (d) 281 pm, 2

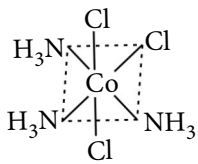
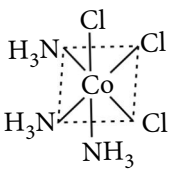
9. Phenol $\xrightarrow[\text{Distillation}]{\text{Zn}}$ A $\xrightarrow[\text{conc. } H_2SO_4, 333\text{ K}]{\text{Conc. } HNO_3}$ B $\xrightarrow[NaOH_{(aq.)}]{\text{Zn}}$ C

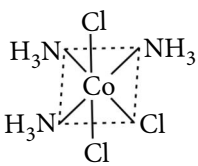
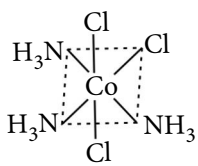
In the above reaction sequence, A, B and C respectively are

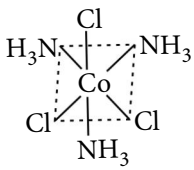
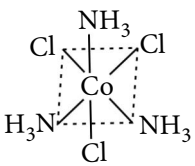
(a) benzene, nitrobenzene, aniline
(b) benzene, *m*-dinitrobenzene, *m*-nitroaniline
(c) toluene, *m*-nitrotoluene, *m*-toluidine
(d) benzene, nitrobenzene, hydrazobenzene.

10. Which of the following pairs of structures represents facial and meridional isomers respectively?

(a)  and 

(b)  and 

(c)  and 

(d)  and 

11. A gas '*X*' is passed through water to form a saturated solution. The aqueous solution on treatment with silver nitrate gives a white precipitate. The saturated aqueous solution also dissolves magnesium ribbon with evolution of a colourless gas '*Y*'.

'*X*' and '*Y*' respectively are

(a) CO_2, Cl_2 (b) Cl_2, CO_2
(c) Cl_2, H_2 (d) H_2, Cl_2

12. A certain buffer solution contains equal concentration of X^- and HX. If K_b for X^- is 10^{-10}, calculate the pH of buffer.

(a) 1 (b) 2
(c) 3 (d) 4

13. Which of the following compounds would have the smallest value for pK_a?

(a) $CHF_2CH_2CH_2COOH$
(b) $CH_3CH_2CF_2COOH$
(c) $CH_3CF_2CH_2COOH$
(d) $CH_3CH_2CH_2COOH$

14. The electron gain enthalpies (in kJ mol^{-1}) of halogens *X*, *Y* and *Z* are respectively –349, –333 and –325. Then *X*, *Y* and *Z* respectively are

(a) F, Cl and Br (b) Cl, F and Br
(c) Cl, Br and F (d) Br, Cl and F

15. Arrange in decreasing order, the energy of 2*s* orbital in the atoms H, Li, Na, K.

(a) E_{2s} (H) > E_{2s} (Li) > E_{2s} (Na) > E_{2s} (K)
(b) E_{2s} (H) > E_{2s} (Na) > E_{2s} (Li) > E_{2s} (K)
(c) E_{2s} (H) > E_{2s} (Na) = E_{2s} (K) > E_{2s} (Li)
(d) E_{2s} (K) > E_{2s} (Na) > E_{2s} (Li) > E_{2s} (H)

16. In Cannizzaro reaction given below :

$2PhCHO \xrightarrow{:OH^-} PhCH_2OH + PhCOO^-$

the slowest step is

(a) the attack of $:OH^-$ at the carbonyl group
(b) the transfer of hydride to the carbonyl group
(c) the abstraction of proton from the carboxylic group
(d) the deprotonation of $PhCH_2OH$.

17. Peroxide ion

(i) has five completely filled antibonding molecular orbitals.
(ii) is diamagnetic.
(iii) has bond order one.
(iv) is isoelectronic with neon.

Which of these are correct?

(a) (ii) and (iii) (b) (i), (ii) and (iv)
(c) (i), (ii) and (iii) (d) (i) and (iv)

18. The product formed during β-elimination in the reaction is

I. $(CH_3)_2\overset{\overset{Br}{|}}{C}HCHCH_3 \xrightarrow[C_2H_5ONa]{C_2H_5OH}$

II. $(CH_3)_2CHCH_2CH_2Br \xrightarrow[C_2H_5ONa]{C_2H_5OH}$

(a) only 2-methylbut-2-ene in I and II
(b) 3-methylbut-1-ene in II and 2-methylbut-2-ene and 3-methylbut-1-ene in I
(c) 2-methylbut-2-ene and 3-methylbut-1-ene in II and 2-methylbut-2-ene in I.
(d) none of the above.

19. The reaction, $2AB_{(g)} + 2C_{(g)} \longrightarrow A_{2(g)} + 2BC_{(g)}$ proceeds according to the mechanism :

(I) $2AB \rightleftharpoons A_2B_2$ (fast)
(II) $A_2B_2 + C \longrightarrow A_2B + BC$ (slow)
(III) $A_2B + C \longrightarrow A_2 + BC$ (fast)

What will be the initial rate taking $[AB]$ = 0.2 M and $[C]$ = 0.5 M? The K_c for the step I is 10^2 M^{-1} and rate constant for the step II is 3.0×10^{-3} mol^{-1} L min^{-1}.

(a) 0.0716 M min^{-1} (b) 0.0891 M min^{-1}
(c) 0.006 M min^{-1} (d) 0.0257 M min^{-1}

20. Cyclopropanoic acid $\xrightarrow{NH_3,\ heat} X \xrightarrow{KOH/Br_2} Y \xrightarrow{CHCl_3/KOH_{(alc.)}} Z \xrightarrow{H_3O^+}$ Carboxylic acid (A)

The final product(s) in the above sequence of reactions is/are

(a) HCOOH only (b) HCOOH and Y
(c) CH_3NH_2 and A (d) A and X

21. At 20°C, the osmotic pressure of urea solution is 400 mm. If the solution is diluted and the temperature is raised to 35°C, then the osmotic pressure is found to be 105.3 mm. The solution is diluted to

(a) 6 times (b) 4 times
(c) 2 times (d) 8 times.

22. The ammonia evolved from the treatment of 0.30 g of an organic compound for the estimation of nitrogen was passed in 100 mL of 0.1 M sulphuric acid. The excess of acid required 20 mL of 0.5 M sodium hydroxide solution for complete neutralization. The organic compound is

(a) acetamide (b) benzamide
(c) urea (d) thiourea.

23. Consider the following reactions :

I. $AlH_3 + H^- \longrightarrow AlH_4^-$
II. $H_2O + H^- \longrightarrow H_2 + OH^-$

Select correct statement based on these reactions.

(a) H^- acts as Lewis acid in I and Lewis base in II.
(b) H^- acts as Lewis base in I and Bronsted base in II.
(c) H^- acts as Lewis acid in I and Bronsted acid in II.
(d) H^- acts as Lewis base in I and II.

24. Which of the following oxoacids of phosphorus is a reducing agent and a monobasic acid as well?

(a) H_3PO_2 (b) HPO_3
(c) H_3PO_3 (d) $H_4P_2O_5$

25. An oxide of nitrogen has vapour density 46. Find the total number of electrons in its 92 g.

(a) 46 N_A (b) $\frac{N_A}{46}$
(c) 92 N_A (d) $\frac{N_A}{92}$

26. A hexapeptide has the composition Ala, Gly, Phe, Val. Both the N-terminal and C-terminal units are Val. Cleavage of the hexapeptide by chemotrypsin gives two different tripeptides, both having Val as the N-terminal group. Among the products of random hydrolysis, one is Ala-Val dipeptide fragment. What is the primary structure of the hexapeptide?

(a) Val-Gly-Phe-Val-Ala-Val
(b) Val-Ala-Phe-Val-Gly-Val
(c) Val-Gly-Ala-Val-Phe-Val
(d) Val-Phe-Val-Ala-Gly-Val

27. The freezing point depression of 0.1 molal solution of acetic acid in benzene is 0.256 K, K_f for benzene is 5.12 K kg mol^{-1}. What conclusion can you draw about the molecular state of acetic acid in benzene?

(a) Acetic acid is doubly associated.
(b) Benzene is doubly associated.
(c) Both are equally associated.
(d) None of the above.

28. N_2 is passed through overheated CaC_2. Which of the following statements are correct for the product formed?

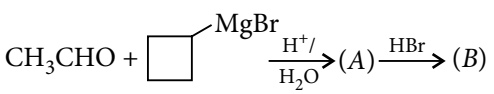
I. State of hybridisation of C is *sp*.
II. Urea is an intermediate formed during hydrolysis of the above product.
III. Anion present in the product is not a pseudohalide ion.
IV. Hydrolysis of the product gives rise to NH_3 gas slowly.

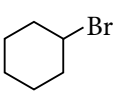
(a) I, II and III (b) III and IV
(c) I, II and IV (d) None of these.

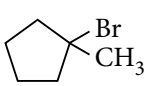
29. A vessel has two equal compartments *A* and *B* containing H_2 and O_2 respectively, each at 1 atm pressure. If the wall separating the compartment is removed, the pressure

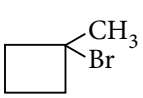
(a) will remain unchanged in *A* and *B*
(b) will increase in *A* and decrease in *B*
(c) will decrease in *A* and increase in *B*
(d) will increase in both *A* and *B*.

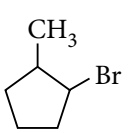
30. Identify the final product in the reaction,



(a) 

(b) 

(c) 

(d) 

SOLUTIONS

1. **(b) :** (i) $\underset{\text{Ethylene}}{CH_2=CH_2} + 3O_2 \longrightarrow 2CO_2 + 2H_2O$

$12\ cm^3 \qquad 36\ cm^3$

(ii) $\underset{\text{Propylene}}{CH_3CH=CH_2} + \frac{9}{2}O_2 \longrightarrow 3CO_2 + 3H_2O$

$12\ cm^3 \qquad 12 \times \frac{9}{2} = 54\ cm^3$

Thus, 12 cm^3 of propylene requires 54 cm^3 of O_2 and hence, cylinder contains only propylene.

2. **(b) :** (a) $Zn \mid Zn^{2+}\ (1\ M) \mid\mid Mg^{2+}\ (1\ M) \mid Mg$

$E^\circ_{cell} = E^\circ_{cathode} - E^\circ_{anode} = E^\circ_{Mg^{2+}/Mg} - E^\circ_{Zn^{2+}/Zn}$
$= -2.37 - (-0.76) = -1.61\ V$

$\Delta G^\circ = -nFE^\circ_{cell} = -2 \times 96500 \times (-1.61)$
$= +310{,}730$

(b) $Zn \mid Zn^{2+}\ (1\ M) \mid\mid Ag^{+}\ (1\ M) \mid Ag$

$E^\circ_{cell} = E^\circ_{Ag^+/Ag} - E^\circ_{Zn^{2+}/Zn}$
$= 0.80 - (-0.76) = +1.56\ V$

$\Delta G^\circ = -nFE^\circ_{cell} = -2 \times 96500 \times 1.56 = -301{,}080$

(c) $Cu \mid Cu^{2+}\ (1\ M) \mid\mid Ag^{+}\ (1\ M) \mid Ag$

$E^\circ_{cell} = E^\circ_{Ag^+/Ag} - E^\circ_{Cu^{2+}/Cu} = 0.80 - 0.34 = +0.46\ V$

$\Delta G^\circ = -nFE^\circ_{cell} = -2 \times 96500 \times 0.46 = -88{,}780$

(d) $Ag \mid Ag^{+}\ (1\ M) \mid\mid Mg^{2+}\ (1\ M) \mid Mg$

$E^\circ_{cell} = E^\circ_{Mg^{2+}/Mg} - E^\circ_{Ag^+/Ag} = -2.37 - 0.80 = -3.17\ V$

$\Delta G^\circ = -nFE^\circ_{cell} = -2 \times 96500 \times (-3.17)$
$= +611{,}810$

3. **(c) :** $Fe + Cu^{2+} \longrightarrow Fe^{2+} + Cu$ …(i)

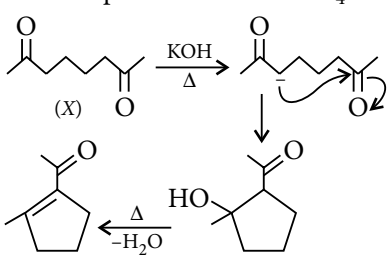
$E^\circ = E^\circ_{Fe/Fe^{2+}} + E^\circ_{Cu^{2+}/Cu} = 0.44 + 0.34 = 0.78\ V$

Thus, reaction (i) is spontaneous means Fe displaces Cu from $CuSO_4$ solution.

$2Ag + Cu^{2+} \longrightarrow 2Ag^{+} + Cu$ …(ii)

$E^\circ = E^\circ_{Ag/Ag^+} + E^\circ_{Cu^{2+}/Cu} = -0.80 + 0.34 = -0.46\ V$

Thus, reaction (ii) is not spontaneous means Ag cannot displace Cu from $CuSO_4$ solution.

4. **(b) :** 

5. **(a) :** $S_{2(g)} + 2O_{2(g)} \longrightarrow 2SO_{2(g)}$; $\Delta G = -544$ kJ …(i)

$2Zn_{(s)} + S_{2(g)} \longrightarrow 2ZnS_{(s)}$; $\Delta G = -293$ kJ …(ii)

$2Zn_{(s)} + O_{2(g)} \longrightarrow 2ZnO_{(s)}$; $\Delta G = -480$ kJ …(iii)

The required equation is

$2ZnS_{(s)} + 3O_{2(g)} \longrightarrow 2ZnO_{(s)} + 2SO_{2(g)}$

which is obtained by (i) + (iii) – (ii)

$\therefore \quad \Delta G = -544 + (-480) - (-293)$

$= -544 - 480 + 293 = -731$ kJ

6. **(d) :** (a) FeO > Fe_2O_3 (basic).

(b) $FeCl_2$ > $FeCl_3$ (ionic), higher the charge, greater the polarizing power and thus, greater the covalent nature.

(c) Fe^{2+} salts are more ionic hence, less volatile than Fe^{3+} salts.

(d) Greater the covalent nature, more easily they are hydrolysed. Thus, $FeCl_3$ is more easily hydrolysed than $FeCl_2$.

7. **(b) :** According to Fajan's rule, the smaller the size and higher the charge on the cation, greater is the covalent character of the ionic bond. Hence, $BeCl_2$ is most covalent *i.e.*, least ionic character while RbCl is least covalent *i.e.*, most ionic character.

8. **(a) :** $\rho = \dfrac{Z \times \text{mol. wt.}}{a^3 \times N_A}$

$\Rightarrow \quad 2.165 = \dfrac{Z \times 58.5}{(562 \times 10^{-10})^3 \times 6 \times 10^{23}} \Rightarrow Z = 4$

$\therefore$ *AB* has *fcc* structure,

$\therefore \quad d_{A^+ - B^-} = \dfrac{a}{2} = \dfrac{562}{2} = 281$ pm

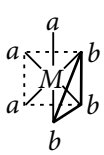
9. **(d) :** $C_6H_5OH \xrightarrow[\text{distillation}]{Zn} C_6H_6 \xrightarrow[333\ K]{HNO_3 + H_2SO_4} C_6H_5NO_2$

Phenol — Benzene (*A*) — Nitrobenzene (*B*)

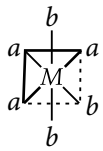
$C_6H_5NO_2 \xrightarrow{Zn/NaOH_{(aq.)}} C_6H_5NH{-}NHC_6H_5$

Nitrobenzene (*B*) — Hydrazobenzene (*C*)

10. **(a) :** **In octahedral complex $[Ma_3b_3]$ Facial (*fac*) :** 3 donor atoms of same ligands occupy adjacent positions at the corners.



Meridional (*mer*) : When the positions are around the meridian.



11. **(c) :** $\underset{(X)}{Cl_2\uparrow} + H_2O \longrightarrow HClO + HCl$

$AgNO_3 + HCl \longrightarrow \underset{\text{White ppt.}}{AgCl\downarrow} + HNO_3$

$Mg + 2HCl \longrightarrow MgCl_2 + \underset{(Y)}{H_2\uparrow}$

12. **(d) :** According to Handerson's equation,

$$pH = -\log K_a + \log \frac{[Salt]}{[Acid]} \qquad \ldots(i)$$

Given that, $K_b = 10^{-10}$

and $K_a \times K_b = 10^{-14}$

$\therefore \quad K_a = \dfrac{10^{-14}}{10^{-10}} = 10^{-4}$

and [Salt] = [Acid]

Putting these values in eq. (i),

$pH = -\log 10^{-4} = 4$

13. **(b) :** Smallest value of pK_a means strongest acid, *–I*-effect of F is maximum in $CH_3CH_2CF_2COOH$ and hence, it is the strongest acid.

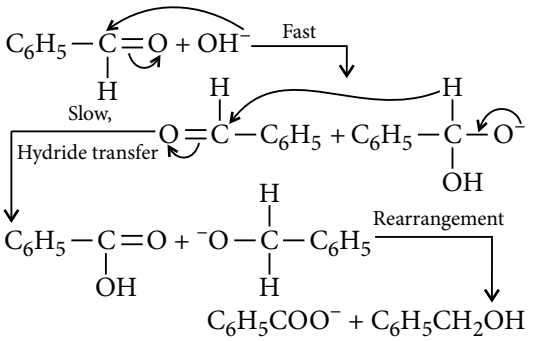
14. **(b) :** Amongst halogens, chlorine has most negative electron gain enthalpy. So, the correct order is

Cl(–349) > F(–333) > Br(–325) > I(–296)

15. **(a) :** As atomic number (nuclear charge) increases, all the orbitals are pulled closer to the nucleus. Closer is an orbital to the nucleus, less is its energy.

16. **(b) :** Rate determining step is always the slowest step. In case of Cannizzaro reaction, H^- transfer to the carbonyl group is the rate determining step and hence the slowest.

Mechanism :



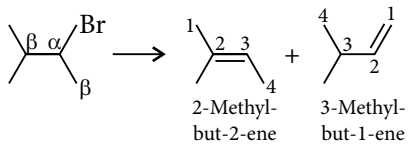
17. (a) : Peroxide ion is O_2^{2-}

O_2^{2-} (18) : $\sigma 1s^2, \sigma^* 1s^2, \sigma 2s^2, \sigma^* 2s^2, \sigma 2p_z^2, (\pi 2p_x^2 = \pi 2p_y^2), (\pi^* 2p_x^2 = \pi^* 2p_y^2)$

$$\text{Bond order} = \frac{N_b - N_a}{2} = \frac{10-8}{2} = 1$$

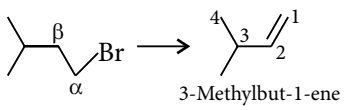
It contains four completely filled antibonding molecular orbitals. Since, all the electrons are paired, O_2^{2-} is diamagnetic. Peroxide ion is isoelectronic with argon, not with neon.

18. (b) : I.



2-Methyl-but-2-ene 3-Methyl-but-1-ene

II.



3-Methylbut-1-ene

19. (c) : Rate of reaction = Rate of step II (the slowest step)

$\Rightarrow$ Rate of reaction $\propto [A_2B_2][C] = k[A_2B_2][C]$ …(i)

where k is the rate constant, of step II.

The equilibrium constant, K_c for the step I is

$$K_c = \frac{[A_2B_2]}{[AB]^2} \Rightarrow [A_2B_2] = K_c[AB]^2$$

Putting this in equation (i), we get

Rate of reaction $= k \cdot K_c[AB]^2[C]$

$= k'[AB]^2[C]$

$\propto [AB]^2[C]$ …(ii)

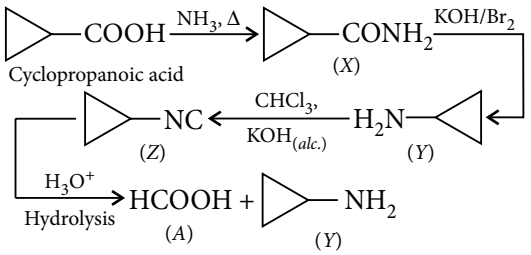
where $k' = k \cdot K_c$ = rate constant of reaction.

Equation (ii) is the rate law of reaction,

initial rate $= 3.0 \times 10^{-3} \times 10^2 \times (0.2)^2(0.5)$

$= 0.3 \times 0.04 \times 0.5 = 0.006$ M min^{-1}

20. (b) :



21. (b) : $\pi = \frac{400}{760}$ atm, $T = 293$ K

Now using, $\pi V = nRT$

$$\frac{400}{760} \times V_1 = n \times R \times 293 \quad \text{…(i)}$$

After dilution, let volume becomes V_2 and temperature is raised to 35°C, *i.e.*, 308 K, and osmotic pressure changes to, $\pi = \frac{105.3}{760}$ atm, then

$$\frac{105.3}{760} \times V_2 = n \times R \times 308 \quad \text{…(ii)}$$

Dividing eqn. (i) by (ii), we get

$$\frac{V_1}{V_2} = \frac{293}{308} \times \frac{105.3}{400} \Rightarrow V_2 = 4V_1$$

Hence, the solution is diluted to 4 times.

22. (c) : Let unreacted 0.1 M(= 0.2 N) $H_2SO_4 = V$ mL

20 mL of 0.5 N (= 0.5 M) NaOH = V mL of 0.2 N H_2SO_4

$$\Rightarrow \quad 20 \times 0.5 = V \times 0.2$$

$$\Rightarrow \quad V = \frac{20 \times 0.5}{0.2} = 50 \text{ mL}$$

Used $H_2SO_4 = 100 - 50 = 50$ mL

% of N

$$= \frac{1.4 \times \text{Normality of acid} \times \text{Vol. of acid used}}{\text{Mass of substance taken}}$$

$$= \frac{1.4 \times 0.2 \times 50}{0.30} = 46.67\%$$

% of N in

(a) $CH_3CONH_2 = \frac{14 \times 100}{59} = 23.73\%$

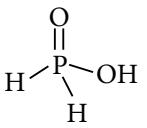
(b) $C_6H_5CONH_2 = \frac{14 \times 100}{121} = 11.57\%$

(c) $NH_2CONH_2 = \frac{28\times100}{60} = 46.67\%$

(d) $NH_2CSNH_2 = \frac{28\times100}{76} = 36.84\%$

23. (b)

24. (a) : Acids which contain P—H bonds have strong reducing properties. Hypophosphorous acid (H_3PO_2) is a good reducing agent as it contains two P—H bonds.



(Monobasic)

25. (a) : Let the oxide of nitrogen be N_2O_x

Mol. wt. of $N_2O_x = 46 \times 2 = 92$

$\therefore$ $2 \times 14 + 16(x) = 92 \Rightarrow x = 4$

$\therefore$ Oxide is N_2O_4

92 g of N_2O_4 = 1 mole of N_2O_4

= N_A molecules of N_2O_4

1 molecule of N_2O_4 has 46 electrons.

$\therefore$ N_A molecules of N_2O_4 has $46 \times N_A$ electrons.

26. (a) : Val-Gly-Phe-Val-Ala-Val, its random hydrolysis gives Ala-Val dipeptide fragment which indicates the connected presence of Ala and Val.

27. (a) : $i = \frac{\text{observed colligative property}}{\text{calculated colligative property}}$

$= \frac{0.256}{0.512} = \frac{1}{2}$

Also, $i = \frac{\text{calculated molecular mass}}{\text{observed molecular mass}}$

Calculated molecular mass of $CH_3COOH = 60$

$\therefore$ Observed molecular mass = $\frac{60}{1/2} = 120$

Hence, acetic acid exists as doubly associated.

28. (c) : $CaC_2 + N_2 \xrightarrow{1100°C}$ CaNCN + C

Calcium cyanamide

$Ca^{2+}[N = C = N]^{2-}$

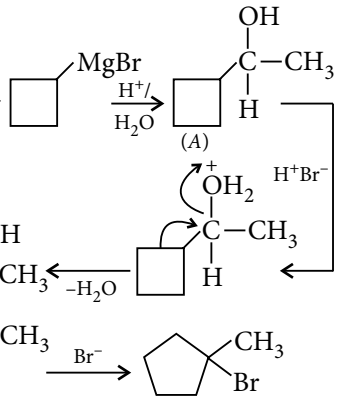
linear shape (*sp*-hybridised C- atom)

On hydrolysis, calcium cyanamide gets converted into urea which then decomposes into ammonia.

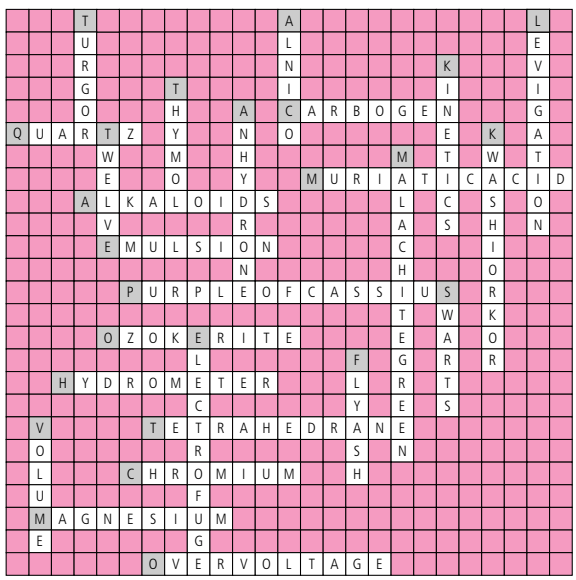
CN_2^{2-} is pseudohalide ion.

29. (a) : Initially the product PV in compartments A and $B = 1 \times V + 1 \times V = 2V$ if volume of each compartment is V.

Now PV = constant at constant temperature and if wall is removed, then V becomes $2V$, thus pressure should be 1 atm to have PV constant.

30. (b) : CH_3CHO + 

SOLUTIONS TO JANUARY 2015 CROSSWORD



Winners of January 2015 Crossword

Arindam Sen, Purulia (West Bengal)

A.K Prasad, Guwahati (Assam)

Venkatesh Purushotham : Crossword helps us to explore and enhances our thinking capacity.

Senders of December 2014 Crossword

Rushikesh Joshi, Nagpur (Maharashtra)

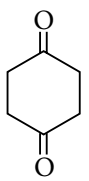
CONCEPT BOOSTER

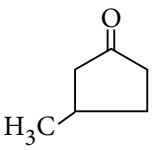
Dear students !! Already the bell has rung and you all are ready to welcome the season of exams. Now, the only mantra is practice, practice and practice. Every week take atleast two full length tests. Presenting JEE Advanced practice paper in organic chemistry. The major thing is, you have to finish it within 45 minutes. Its solutions will be published in the next issue. Till then good bye !!

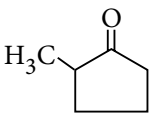
*Arunava Sarkar

ONLY ONE OPTION CORRECT TYPE

1. $(CH_2)_4$(COOH)(COOH) $\xrightarrow{EtO^-Na^+}$?

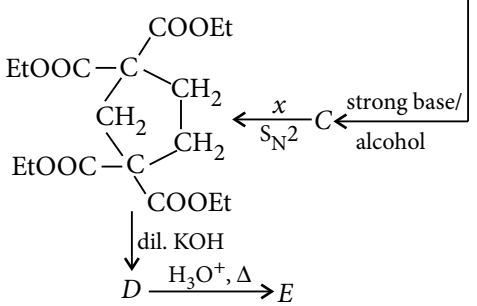
(a) 

(b) 

(c) 

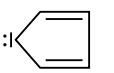
(d) None of these.

2. $2CH_2$(COOEt)(COOEt) $\xrightarrow[EtOH]{EtO^-Na^+ (excess)}$ A $\xrightarrow[S_N2]{CH_2I_2}$ B



Identify x and E (which should be most suitable).

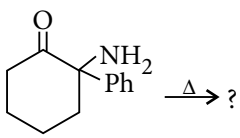
(a) $x = CH_2I_2/Zn$; $E =$ 

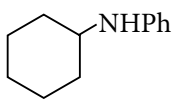
(b) $x =$  , $E =$ 

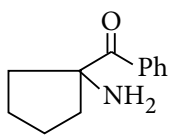
(c) $x =$  , $E =$ 

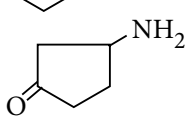
(d) None of these.

3. Identify the product.



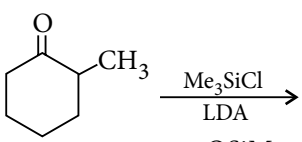
(a) 

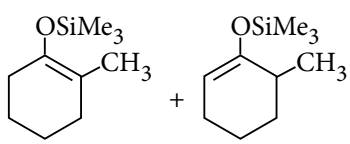
(b) 

(c) 

+ PhH

(d) None of these.

4. 



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(a) x is slightly greater than y.
(b) x is slightly lesser than y.
(c) y is largely greater than x.
(d) Reaction does not proceed without heat.

5. $CH_3-\underset{\underset{O}{\|}}{C}-CH_3 \xrightarrow{SeO_2}$ Methylglyoxal

Which of the following statements is correct?

(a) Reaction is in between SeO_2 and $CH_3-\underset{\underset{O}{\|}}{C}-CH_3$ directly.

(b) Reaction is in between SeO_2 and $CH_2=\underset{\underset{O-H}{|}}{C}-CH_3$ actually.

(c) Reaction is in between H_2SeO_3 and CH_3COCH_3.

(d) None of these.

6. Identify the product.

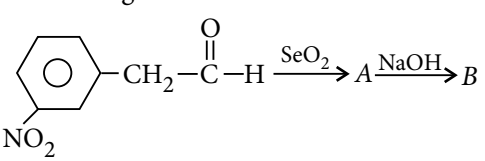
$CD_3CHO + 4HCHO \xrightarrow{\bar{O}H}$?

(a) $HOH_2C-\underset{\underset{CH_2OH}{|}}{\overset{\overset{CH_2OH}{|}}{C}}-CH_2OH$

(b) $\begin{matrix} D \\ D \\ D \end{matrix}\!\!>\!C-CH(OH)-CH_2OH$ (only one HCHO will participate)

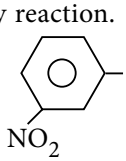
(c) Conditions are not sufficient for the reaction to occur.

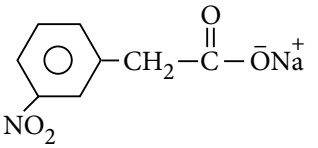
(d) CD_3CHO will not take part. HCHO will undergo Cannizzaro reaction.

7. 

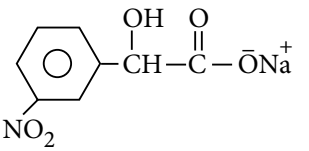
Identify B in the reaction sequence.

(a) $-NO_2$ group at the *meta* position will deactivate the ring and it will not allow any reaction.

(b) As  is a big group, SeO_2 will cause oxidation at $-\overset{\overset{O}{\|}}{C}-H$ position and will convert it to —COOH. So, B is



(c) $Ph-\overset{\overset{O}{\|}}{C}-\overset{\overset{O}{\|}}{C}-H + NO_2\uparrow$

(d) 

8. $PhCHO + HCHO \xrightarrow{Ca(OH)_2}$

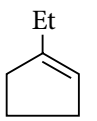
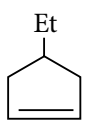
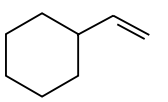
No. of products = ?

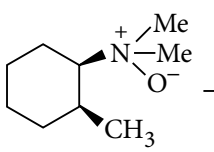
(a) 2 (b) 4
(c) 1
(d) 6 (including crossover products)

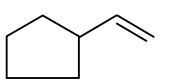
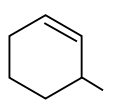
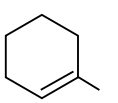
9. $CH_3CH_2-\overset{\overset{O}{\|}}{C}-CH_2CH_2CH_2CH_2-\overset{+}{S}Me_2$

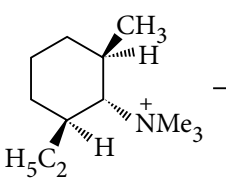
$\xrightarrow{\Delta}$ $\xrightarrow{\ddot{B}u\bar{L}i^+}$ X

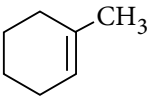
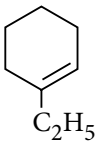
here, X is the major product. Identify X.

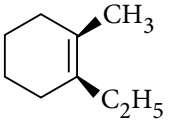
(a) 
(b) 
(c) 
(d) None of these.

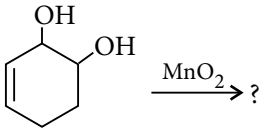
10.  Major product = ?

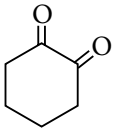
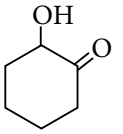
(a) 
(b) 
(c) 
(d) None of these.

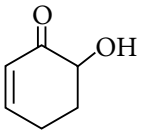
11.  Major product = ?

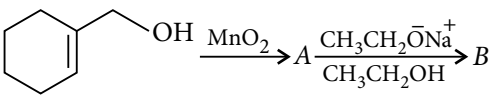
(a)  (b) 

(c)  (d) None of these.

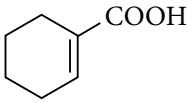
12. 

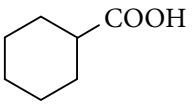
(a)  (b) 

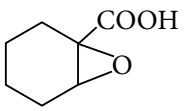
(c)  (d) None of these.

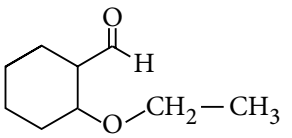
13. 

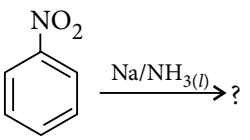
B = ?

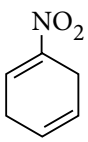
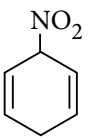
(a) 

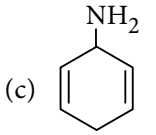
(b) 

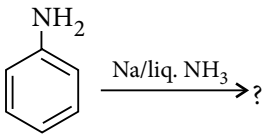
(c) 

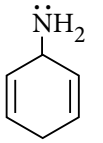
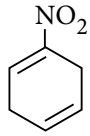
(d) 

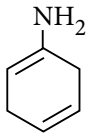
14. 

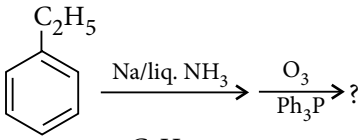
(a)  (b) 

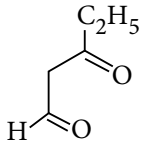
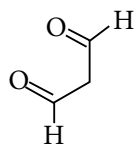
(c)  (d) None of these.

15. 

(a)  (b) 

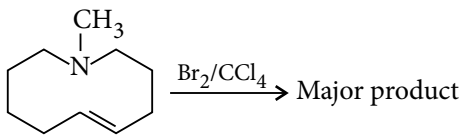
(c)  (d) None of these.

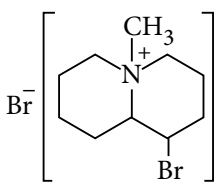
16. 

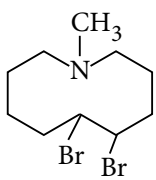
(a)  (b) 

(c) Both (a) and (b).

(d) None of these.

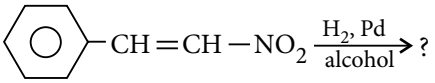
17. 

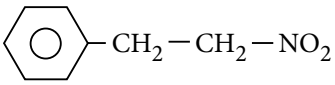
(a) 

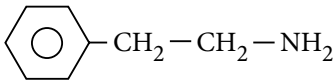
(b) 

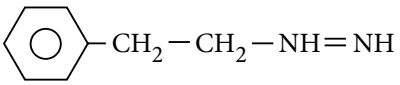
(c) No attack as no stable product formation is possible.

(d) None of these.

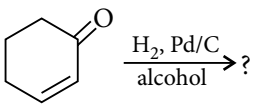
18. 

(a) 

(b) 

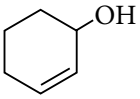
(c) 

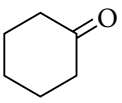
(d) None of these as double bond is in conjugation with the ring.

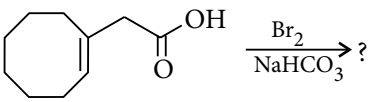
19. 

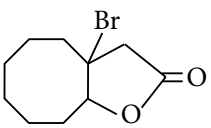
(a) 

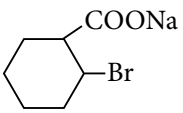
(b) 

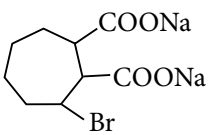
(c) 

(d) 

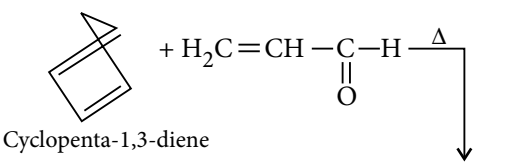
20. 

(a) 

(b) 

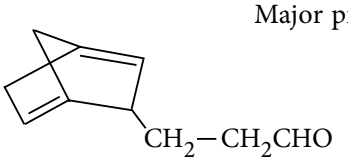
(c) 

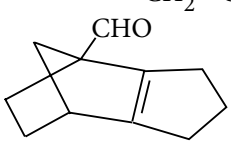
(d) None of these.

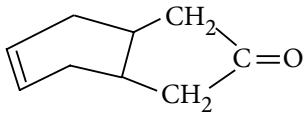
21. 

Cyclopenta-1,3-diene

Major product = ?

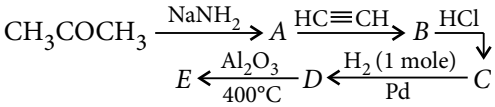
(a) 

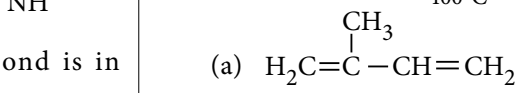
(b) 

(c) 

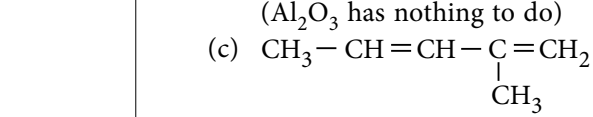
(d) None of these.

22. Identify *E* in the given reaction sequence.



(a) 

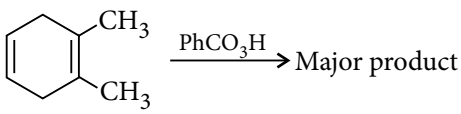
(b) $CH_3-CH_2-CH_2-CH_2-CH_3$
(Al_2O_3 has nothing to do)

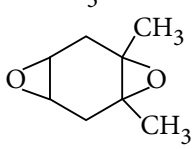
(c) 

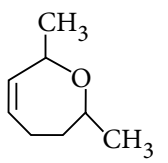
(d) None of these.

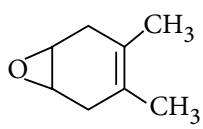
23. From the following set of compounds how many will give the positive iodoform test?
acetophenone, pentanal, 3-pentanone, ethanol, 2-butanol, ethanal, 3-pentanol, phenacyl iodide

(a) 3 (b) 4
(c) 5 (d) 6

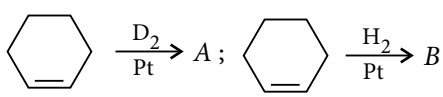
24. 

(a) 

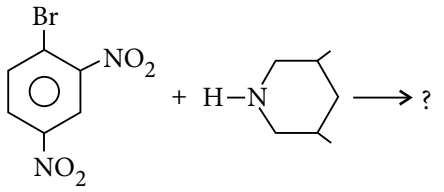
(b) 

(c) 

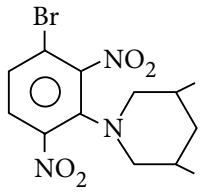
(d) None of these.

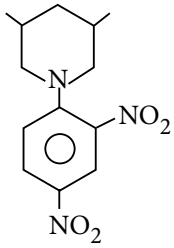
25. 

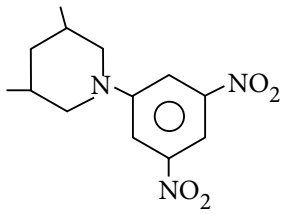
(a) *A* and *B* both are syn products.
(b) *A* is anti but *B* is syn product.
(c) *B* is syn but *A* is not possible without heat.
(d) *A* is syn, without heat *B* is also syn.

26. 

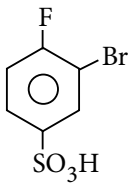
Identify the product.

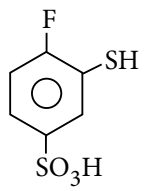
(a) 

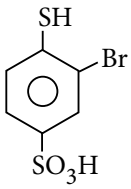
(b) 

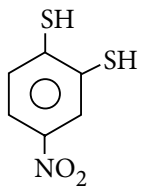
(c) 

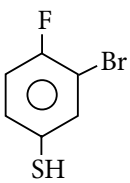
(d) No reaction due to steric hindrance.

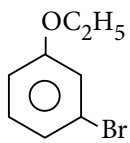
27. 

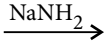
(a) 

(b) 

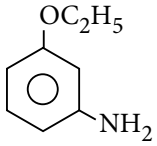
(c) 

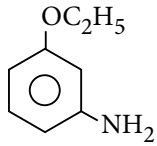
(d) 

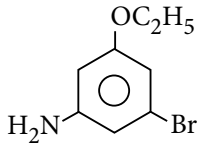
28. 

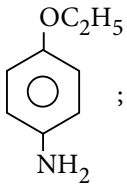


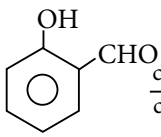
Which of the following best describes the major product and nature of the reaction?

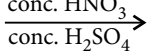
(a)  ; elimination-addition

(b)  ; addition-elimination

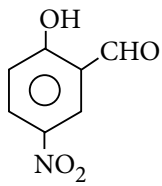
(c)  ; cine substitution

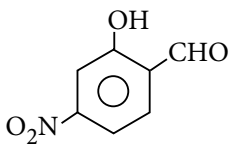
(d)  ; elimination-substitution

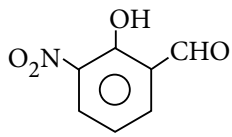
29. 

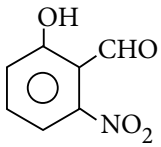


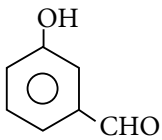
(Major)

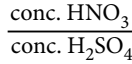
(a) 

(b) 

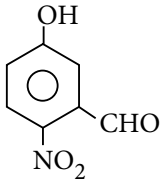
(c) 

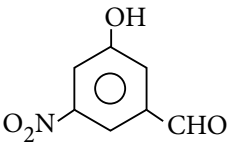
(d) 

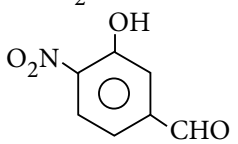
30. 



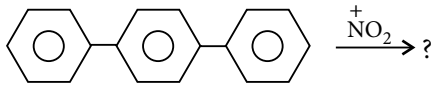
(Major)

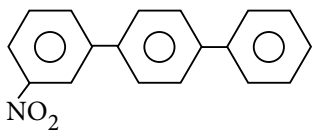
(a) 

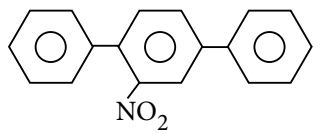
(b) 

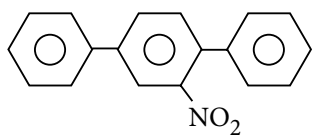
(c) 

(d) None of these.

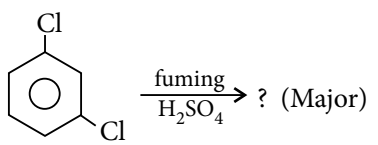
31. 

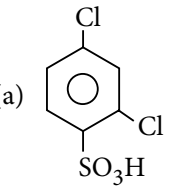
(a) 

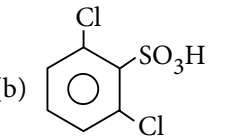
(b) 

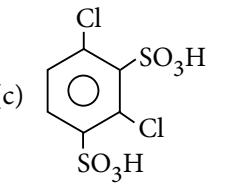
(c) 

(d) Both (b) and (c).

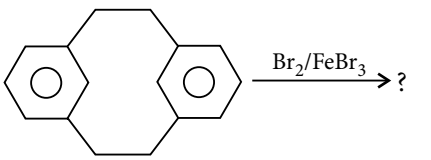
32. 

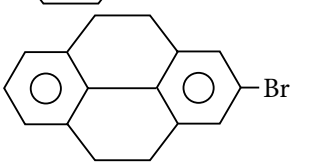
(a) 

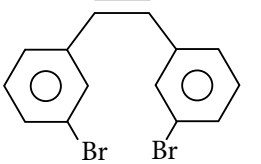
(b) 

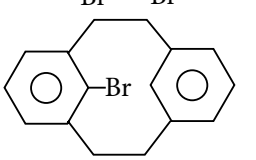
(c) 

(d) None of these.

33. 

(a) 

(b) 

(c) 

(d) None of these.

Foundation Series

JEE

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UNIT-8 Biomolecules | Polymers | Chemistry in Everyday Life

BIOMOLECULES

- Carbohydrates
- Vitamins
- Proteins
- Nucleic Acids

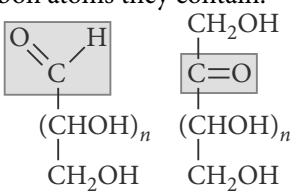
TIPS TO REMEMBER

CARBOHYDRATES

- Carbohydrates are optically active polyhydroxy aldehydes or ketones or the compounds that can be broken down or hydrolysed into polyhydroxy aldehydes or ketones.
  - These are referred to as saccharides because of sweet taste of the simpler members of the class.
- **Reducing sugars:** Contain free aldehydic or ketonic groups and reduce Fehling's solution and Tollens' reagent.
  - All monosaccharides and disaccharides having free aldehydic or ketonic groups are reducing sugars. *e.g.*, maltose and lactose.
- **Non-reducing sugars:** Do not have free aldehydic or ketonic groups and do not reduce Fehling's solution and Tollens' reagent.
  - In disaccharides, if the reducing groups of monosaccharides, *i.e.* aldehydic or ketonic groups are bonded, they are non-reducing in nature. *e.g.*, sucrose.
  - All polysaccharides are non-reducing in nature. *e.g.*, cellulose, starch, glycogen etc.
- Depending on the number of products obtained on hydrolysis, carbohydrates are divided into three major classes:
  - Monosaccharides: $(CH_2O)_n$, n = 3-7
  - Oligosaccharides: $(C_6H_{10}O_5)_n$, n = 2–10
  - Polysaccharides: $(C_6H_{10}O_5)_n$, n = 100 – 3000

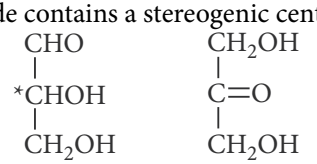
Monosaccharides

- Monosaccharides which contain an aldehyde group (—CHO) are called aldoses and those which contain a keto group ($\rangle C{=}O$) are called ketoses.
  - They are further classified as trioses, tetroses, etc. depending upon the number of carbon atoms they contain.



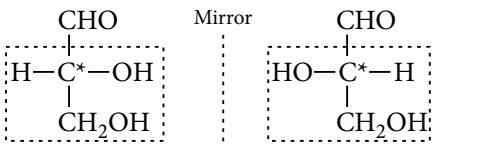
An aldose A ketose

- The simplest monosaccharides are glyceraldehyde and dihydroxyacetone.
  - Of these two compounds, only glyceraldehyde contains a stereogenic centre.



Glyceraldehyde (An aldotriose) Dihydroxyacetone (A ketotriose)

- Except ketotriose (dihydroxyacetone), all aldoses and ketoses (monosaccharides) contain asymmetric carbon atoms and are optically active.
- The sugars are divided into two families, the *D*-family and *L*-family on the basis of configuration of the simplest sugar glyceraldehyde which exists in two enantiomeric forms.



D-form (Glyceraldehyde) (—OH group on the right side of lowest asymmetric carbon)

L-form (Glyceraldehyde) (—OH group on the left side of lowest asymmetric carbon)

- A monosaccharide is assigned *D*-configuration if the —OH group at the last chiral carbon atom lies towards right hand side like that in *D*-(+)-glyceraldehyde. On the other hand, it is assigned *L*-configuration if the —OH group on the last chiral carbon atom lies on the left hand side like that in *L*-(–)-glyceraldehyde.
  - All naturally occurring monosaccharides belong to *D*-series.

KEY POINT

- The (+) and (–) signs only specify the direction of rotation of the plane polarized light by a particular enantiomer but it does not give any indication of the arrangement of —OH and —H around the asymmetric carbon atom.

Glucose

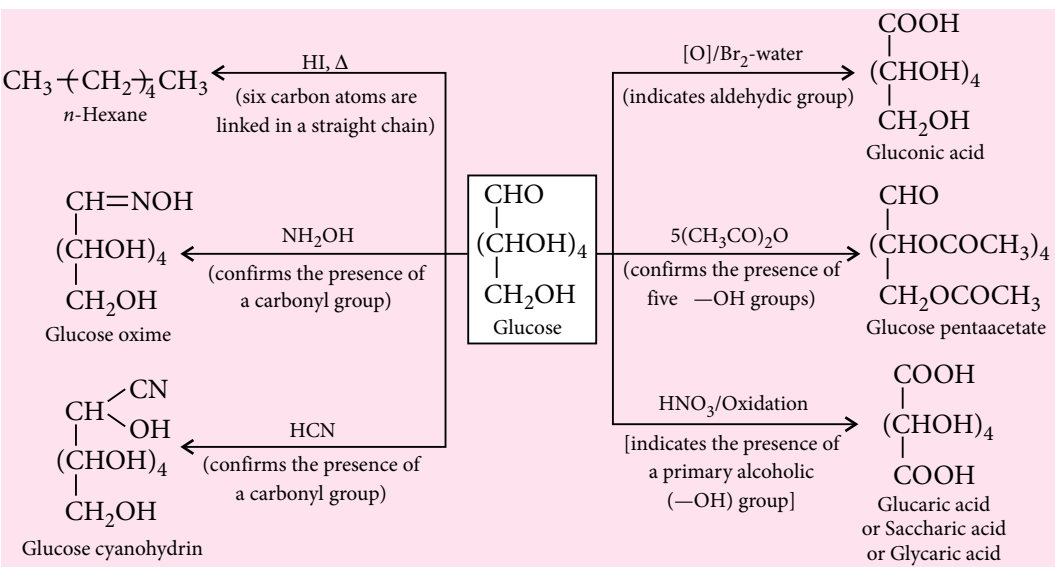
- It is an aldohexose having formula $C_6H_{12}O_6$. Also called *D*-(+)-glucose or dextrose or grape sugar.
- **Preparation**
  - **Laboratory method:** From sucrose (cane sugar)

$$\underset{\text{Sucrose}}{C_{12}H_{22}O_{11}} + H_2O \xrightarrow{H^+} \underset{\text{Glucose}}{C_6H_{12}O_6} + \underset{\text{Fructose}}{C_6H_{12}O_6}$$

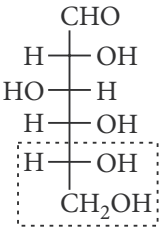
  - **Commercial method:** From starch

$$\underset{\text{Starch or Cellulose}}{(C_6H_{10}O_5)_n} + nH_2O \xrightarrow[393\text{ K, 2-3 atm}]{H^+/\Delta} \underset{\text{Glucose}}{nC_6H_{12}O_6}$$

- **Physical Properties**
  - It is a colourless, crystalline solid, melts at 146 °C and is less sweet (three-fourth) than cane sugar.
  - It is readily soluble in water, sparingly soluble in alcohol but insoluble in ether.
  - It is optically active and the ordinary naturally occurring form is (+)-glucose or dextro form. It shows mutarotation.
- **Structure**

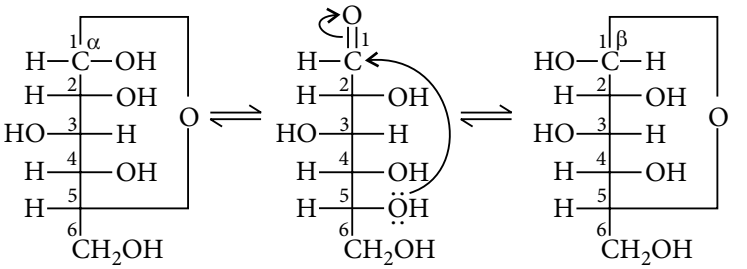


- The exact spatial arrangement of different —OH groups was given by Fischer.



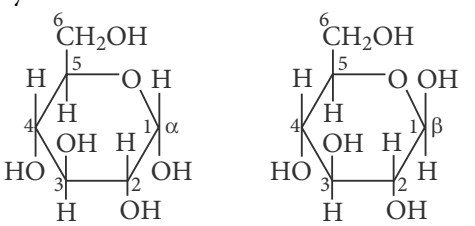
D-(+)-Glucose

- Despite having the aldehyde group, it does not give 2,4-DNP test, Schiff's test and it does not form the hydrogensulphite addition product with $NaHSO_3$.
- The pentaacetate of it does not react with hydroxylamine indicating the absence of free —CHO group.
- The above behaviour could not be explained by the open chain structure.



α-*D*-(+)-Glucopyranose *D*-(+)-Glucose β-*D*-(+)-Glucopyranose

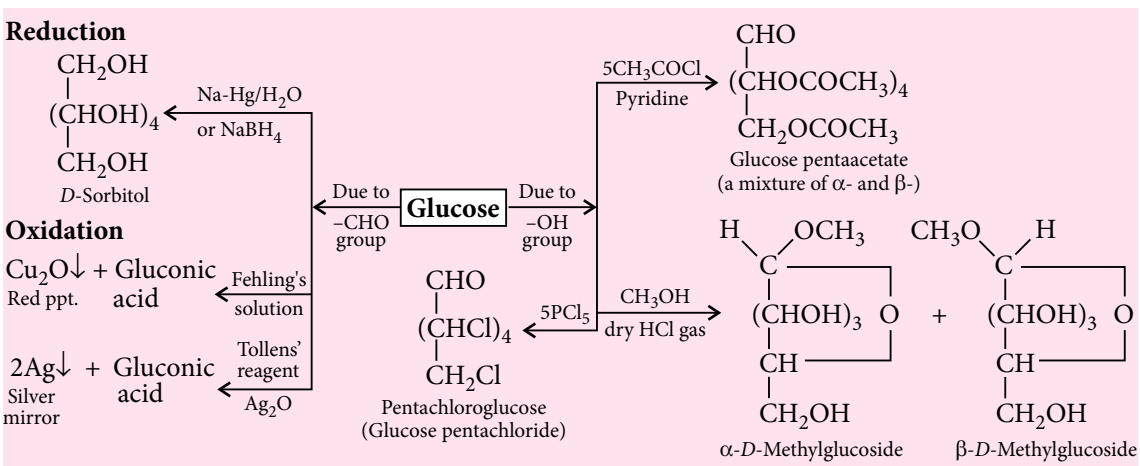
- The cyclic structure of glucose is represented by Haworth structure.



α-*D*-(+)-Glucopyranose β-*D*-(+)-Glucopyranose

- α and β-*D*-glucose have different configuration at anomeric (C-1) carbon atom, hence are called anomers and the C-1 carbon atom is called anomeric carbon (glycosidic carbon).
- The six membered cyclic structure of glucose is called pyranose structure.

Chemical Reactions



KEY POINT

- α and β-*D*-glucose are diastereomers.
- Any pair of diastereomers that differ in configuration at only a single tetrahedral stereogenic carbon are called epimers. *e.g.* *D*-glucose and *D*-mannose.
- All monosaccharides and reducing disaccharides react with excess of phenylhydrazine to form crystalline osazones.
- During osazone formation, only C_1 and C_2 are involved, therefore, all monosaccharides which differ in configuration at C_1 and C_2 like glucose, mannose and fructose give the same osazone.

SELF CHECK

1. α-*D*-(+)-glucose and β-*D*-(+)-glucose are
   (a) enantiomers (b) conformers
   (c) epimers (d) anomers.
   (AIEEE 2008)
2. The term anomers of glucose refers to
   (a) isomers of glucose that differ in configurations at carbons one and four (C-1 and C-4)
   (b) a mixture of (*D*)-glucose and (*L*)-glucose
   (c) enantiomers of glucose
   (d) isomers of glucose that differ in configuration at carbon one (C-1).
   (AIEEE 2006)

❑ **Tests**

Reagents	Observations
With little conc. H_2SO_4	Charred residue of carbon.
With dilute NaOH	First yellow and then brown.
Molisch's test: Two drops of alcoholic solution of α-naphthol + 2 mL of glucose solution + conc. H_2SO_4 along the sides of test tube.	Violet ring at the junction of two liquids.
Silver mirror test: With Tollens' reagent	Silver mirror appears.
With Fehling's solution	Red ppt. of Cu_2O.

Fructose

❑ It is a ketohexose having formula $C_6H_{12}O_6$. Also called laevulose or fruit sugar.

❑ **Preparation**

❍ **From sucrose (cane sugar)**

$$\underset{\text{Cane sugar (Dextrorotatory)}}{C_{12}H_{22}O_{11}} + H_2O \xrightarrow[\Delta]{\text{dil. } H_2SO_4} \underset{\text{D-Glucose (Dextrorotatory)}}{C_6H_{12}O_6} + \underset{\text{D-Fructose (Laevorotatory)}}{C_6H_{12}O_6}$$

The solution containing equimolar mixture of *D*-(+)-glucose and *D*-(–)-fructose is called invert sugar and the process is known as inversion.

❍ **From inulin**

$$\underset{\text{Inulin}}{(C_6H_{10}O_5)_n} + nH_2O \xrightarrow{\text{dil. } H_2SO_4} \underset{\text{Fructose}}{nC_6H_{12}O_6}$$

❑ **Physical Properties**

❍ The anhydrous fructose is a colourless, crystalline compound, melts at 102 °C.

❍ It is soluble in water but insoluble in benzene and ether.

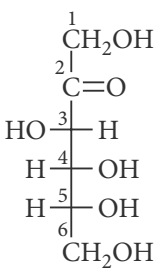
❍ It is the sweetest of all sugars.

❍ Its solution is laevorotatory.

❍ Like glucose, it also shows mutarotation.

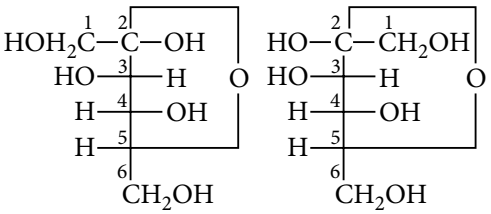
❑ **Structure**

❍ On the basis of its reactions, it was found to contain a ketonic functional group at C-2 atom and six carbon atoms in straight chain as in the case of glucose. It belongs to *D*-series and is appropriately written as *D*-(–)-fructose. Its open chain structure is as shown:



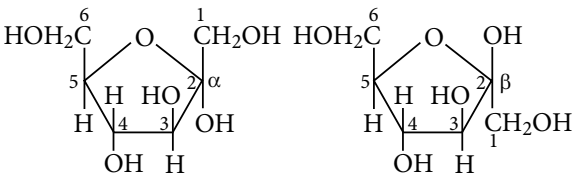
D-(–)-Fructose

- It also exists in two cyclic forms which are obtained by the addition of —OH at C-5 to the >C=O group. The ring, thus formed is a five membered ring and is named as furanose.



α-*D*-(–)-Fructofuranose β-*D*-(–)-Fructofuranose

- The cyclic structures of two anomers of fructose are represented by Haworth structures.



α-*D*-(–)-Fructofuranose β-*D*-(–)-Fructofuranose

Mutarotation

- Glucose exists in two isomeric forms, *i.e.*, α-*D*-glucose (specific rotation = + 111°) and β-*D*-glucose (specific rotation = + 19.2°).
  - However, when aqueous solution of either of these two forms is allowed to stand, it gets converted into an equilibrium mixture of both the α- and the β-forms with a small amount of the open chain form.
  - As a result of this equilibrium, the specific rotation of a freshly prepared solution of α-*D*-glucose decreases from +111° to +52.7° while that of β-*D*-glucose increases from +19.2° to +52.7°.

α-*D*-Glucose ⇌ Equilibrium mixture ⇌ β-*D*-Glucose

$[\alpha]_D$ = +111° $[\alpha]_D$ = + 52.7° $[\alpha]_D$ = +19.2°

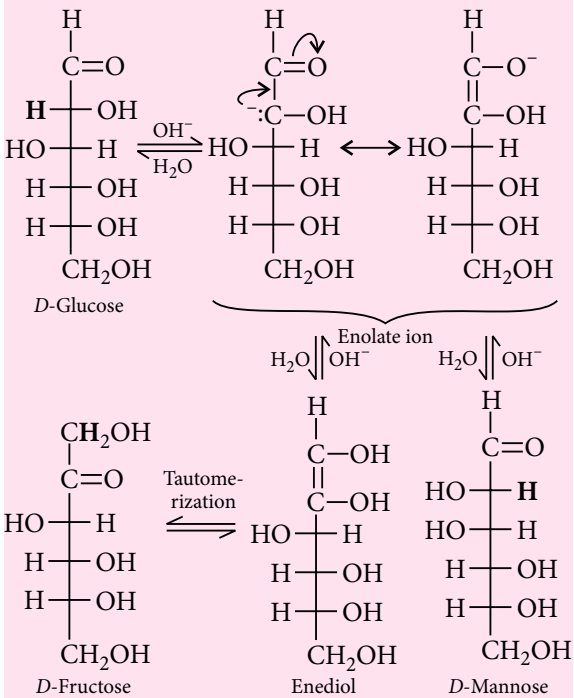
- This change in specific rotation of an optically active compound with time to an equilibrium value is called mutarotation.
  - All monosaccharides and reducing disaccharides undergo mutarotation.
  - Fructose also undergoes mutarotation.

α-*D*-Fructose ⇌ Equilibrium mixture ⇌ β-*D*-Fructose

$[\alpha]_D$ = –21° $[\alpha]_D$ = –92° $[\alpha]_D$ = –133°

KEY POINT

- When glucose is treated with a dilute solution of an alkali, it forms an equilibrium mixture of *D*-glucose, *D*-fructose and *D*-mannose.
- This type of reaction is called Lobry de Bruyn van Ekenstein transformation and occurs via 1, 2-enolization.
- It is because of this, fructose reduces Tollens' reagent and Fehling's solution although it does not contain any —CHO group.



D-Glucose *D*-Fructose Enediol *D*-Mannose

Oligosaccharides

- Depending on the number of monosaccharide units obtained on hydrolysis, oligosaccharides are divided into disaccharides, trisaccharides, tetrasaccharides, etc.

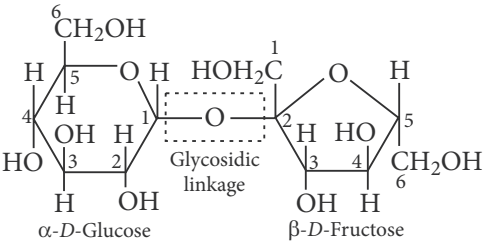
Disaccharides

- Disaccharides are formed when two monosaccharides are joined together by an oxide linkage (glycosidic linkage) formed by the loss of a water molecule.

Sucrose

$$\underset{\substack{\text{(+)-Sucrose}\\ [\alpha]_D = +66.5^\circ}}{C_{12}H_{22}O_{11(s)}} + H_2O \xrightarrow{\text{Hydrolysis}} \underbrace{C_6H_{12}O_{6(aq)} + C_6H_{12}O_{6(aq)}}_{\substack{\text{Invert sugar}\\ D\text{-(+)-Glucose } [\alpha]_D = +52.7^\circ \text{ and}\\ D\text{-(–)-Fructose } [\alpha]_D = -92.4^\circ}}$$

Structure

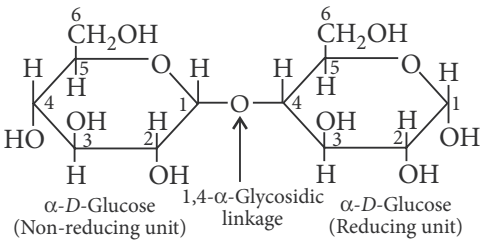


Nature: Non-reducing sugar, dextrorotatory

Maltose

$$\underset{\text{Starch}}{2(C_6H_{10}O_5)_n} + nH_2O \xrightarrow[\text{Diastase}]{\text{Hydrolysis}} \underset{\text{Maltose}}{nC_{12}H_{22}O_{11}}$$

Structure

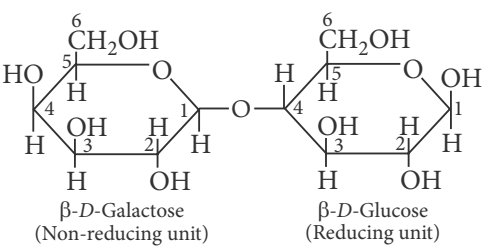


Nature: Reducing sugar, dextrorotatory

Lactose

$$\underset{\text{(+)-Lactose}}{C_{12}H_{22}O_{11(s)}} + H_2O \xrightarrow[\text{Lactase}]{\text{Hydrolysis}} \underset{D\text{-(+)-Glucose}}{C_6H_{12}O_{6(aq)}} + \underset{D\text{-(+)-Galactose}}{C_6H_{12}O_{6(aq)}}$$

Structure



Nature: Reducing sugar, epimeric in nature

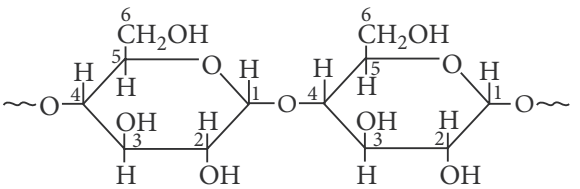
Polysaccharides

- They mainly act as the food storage or structural materials.
- They are non-reducing in nature due to absence of free aldehydic or ketonic groups.
  e.g., starch, cellulose, glycogen, gum etc.

Starch

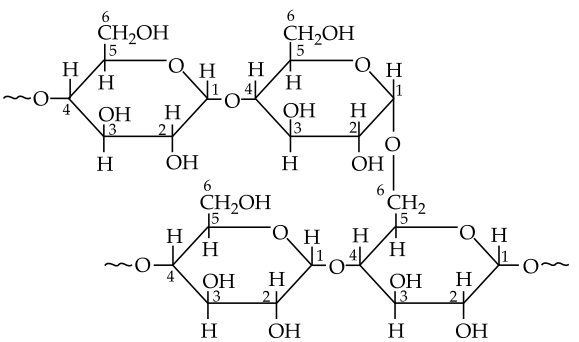
- It is a polymer of α-*D*-glucose.

Amylose



- It is water soluble.
- It constitutes about 15-20% of starch.
- It is a long unbranched chain.

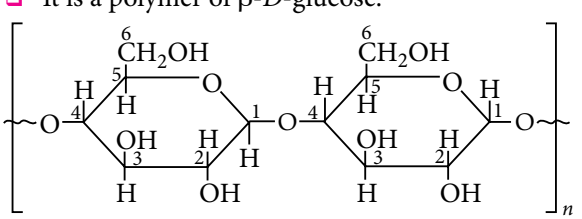
Amylopectin



- It is insoluble in water.
- It constitutes about 80-85% of starch.
- It consists of a large number of short chains each containing 20-25 glucose units joined through 1,4-α-glycosidic linkages. The branching occurs by 1,6-α-glycosidic linkage.

Cellulose

- It is a polymer of β-*D*-glucose.



- It is insoluble in water and in most of the organic solvents.
- It is a linear polymer.

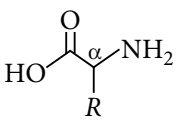
KEY POINT

- Starch and cellulose are the main storage polysaccharides of plants. Cellulose is the major constituent of the cell wall in plants.
- Glycogen is an animal starch. It is a major constituent of liver, muscles and brain. It is also present in fungi and yeast.
- Like amylopectin, glycogen is a branched polymer of α-*D*-glucose; in fact it is more highly branched than amylopectin.

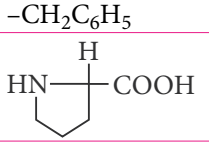
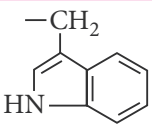
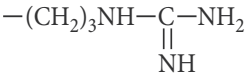
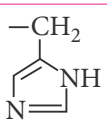
PROTEINS

- Proteins are biologically important compounds.
- They are condensation polymers (polyamides) made up of different simple monomeric units called α-amino acids.

  Proteins $\xrightarrow{\text{Hydrolysis}}$ Peptides $\xrightarrow{\text{Hydrolysis}}$ α-Amino acids
- Amino acids are the bifunctional molecules with both acidic carboxylic group (−COOH) and basic amino group ($-NH_2$).
- In α-amino acids, the amino ($-NH_2$) group is at α-position w.r.t. carboxylic (−COOH) group. *i.e.*, both amino and carboxylic groups are attached to the same carbon atom.



An α-amino acid
R is a side chain at the α carbon that determines the identity of the amino acid

Name of amino acid	Structure of *R*	Three letter symbol
• **Amino acids with non-polar side chain**		
Glycine	–H	Gly
Alanine	$-CH_3$	Ala
*Valine	$-CH(CH_3)_2$	Val
*Leucine	$-CH_2CH(CH_3)_2$	Leu
*Isoleucine	$-CH(CH_3)-CH_2-CH_3$	Ile
*Phenylalanine	$-CH_2C_6H_5$	Phe
Proline		Pro
• **Amino acids with polar but neutral side chain**		
*Tryptophan		Trp
Serine	$-CH_2OH$	Ser
*Threonine	$-CH(OH)CH_3$	Thr
Tyrosine	$-CH_2C_6H_4OH(p)$	Tyr
Cysteine	$-CH_2SH$	Cys
*Methionine	$-CH_2CH_2SCH_3$	Met
Asparagine	$-CH_2CONH_2$	Asn
Glutamine	$-CH_2CH_2CONH_2$	Gln
• **Amino acids with acidic side chain**		
Aspartic acid	$-CH_2COOH$	Asp
Glutamic acid	$-CH_2CH_2COOH$	Glu
• **Amino acids with basic side chain**		
*Lysine	$-(CH_2)_4NH_2$	Lys
*Arginine		Arg
*Histidine		His
*Essential amino acids		

Classification of Amino Acids

- Depending upon the relative number of amino ($-NH_2$) and carboxyl (−COOH) groups.

Neutral
No. of —COOH groups = No. of $-NH_2$ groups
e.g., Glycine, Alanine, Valine

Acidic
No. of —COOH groups > No. of $-NH_2$ groups
e.g., Aspartic acid, Asparagine, Glutamic acid

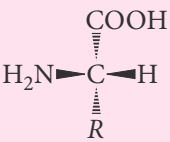
Basic
No. of $-NH_2$ groups > No. of —COOH groups
e.g., Lysine, Arginine, Histidine

- On the basis of their synthesis:

Essential amino acids	Non-essential amino acids
Cannot be synthesised in the body and must be obtained through diet. *e.g.* valine, leucine, lysine, isoleucine, arginine, etc.	Which can be synthesised in the body. *e.g.* glycine, alanine, glutamic acid, aspartic acid, etc.

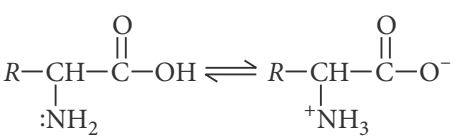
KEY POINT

- With the exception of glycine, almost all naturally occurring amino acids have the *L*-configuration at the α-carbon.



An *L*-α-amino acid

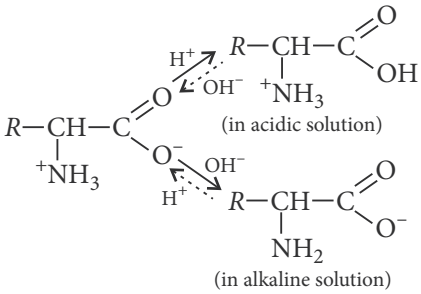
- **Properties**
  - Amino acids are colourless, crystalline substances having sweet taste.
  - They melt with decomposition at higher temperature (more than 200 °C).
  - They are soluble in water but insoluble in organic solvents.
  - Except glycine, all the α-amino acids are optically active and have an asymmetric carbon atom.
  - In aqueous solution, the carboxylic group can lose a proton and amino group can accept a proton giving rise to a dipolar ion known as zwitter ion. This is neutral but contains both positive and negative charges.



Zwitter ion

Therefore, amino acids are amphoteric in nature.

  - Depending on the pH of the solution, the amino acid can donate or accept proton. In the acidic medium, COO^- ion of the zwitter ion accepts a proton to form the cation while in the basic medium, $\overset{+}{N}H_3$ ion loses a proton to form the anion.



(in acidic solution)

(in alkaline solution)

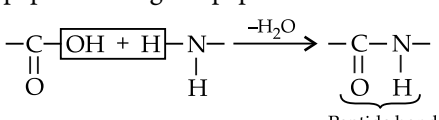
  - In acidic solution (low pH), the positive ion moves towards cathode (exists as cation).
  - In basic solution (high pH), the negative ion moves towards anode (exists as anion).
  - The zwitter ion does not move towards any of the electrodes (neutral dipolar ion).
  - The intermediate pH at which the amino acid shows no tendency to migrate towards any of the electrodes and exists in equilibrium when placed in an electric field is known as isoelectric point.

SELF CHECK

3. Which one of the following statements is correct?
   (a) All amino acids are optically active.
   (b) All amino acids except glycine are optically active.
   (c) All amino acids except glutamic acid are optically active.
   (d) All amino acids except lysine are optically active. (AIEEE 2012)

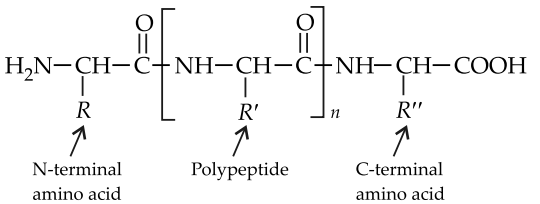
Formation of Proteins

- Proteins are formed by joining the carboxyl group of one amino acid to the amino group of another amino acid.
- The bond formed between two amino acids by the elimination of a water molecule is called a peptide linkage or peptide bond.



Peptide bond

- The products formed by the linking of amino acids by peptide linkage are known as peptides.
  - Peptides containing 2-10 amino acids are called oligopeptides.
  - Peptides containing more than ten amino acids are known as polypeptides.



R, *R*′, *R*″ may be same or different.

  - A polypeptide with more than hundred amino acid residues, having molecular mass higher than 10,000 u is called a protein.

KEY POINT

- Each molecule of a given protein has the same sequence of the amino acids along its polypeptide chain.
- Change of even one amino acid can drastically change the properties of entire protein molecule.

Classification of Proteins

- On the basis of molecular structure, proteins are classified as fibrous and globular proteins.

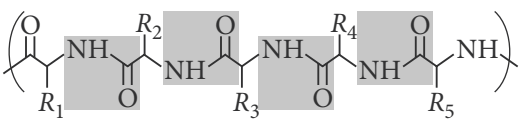
Fibrous proteins

In fibrous proteins, polypeptide chains are parallel and are held together by hydrogen and disulphide bonds. These are insoluble in water, *e.g.*, keratin and myosin.

Globular proteins

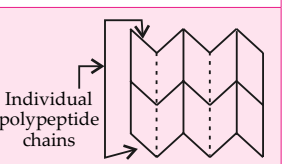
Globular proteins results when the polypeptide chains coil around to give three dimensional spherical shape. These are soluble in water, *e.g.*, insulin and albumin.

- **Primary structure of proteins:** It refers to the number and sequence of the amino acids in its polypeptide chains.



R_1–R_5 may be any of the possible side chains

- **Secondary structure of proteins:** The arrangement of polypeptide chains assumed as a result of hydrogen bonding is called the secondary structure of proteins.
  - The linkage or bonds involved in the secondary structure formation are hydrogen bonds and disulphide bonds.
  - It tells about the shape or configuration of the molecule.
- Depending on the size of the —*R* group, secondary structure of proteins is of two types:

α-Helix	β-Pleated sheet
• It is formed when the chain of α-amino acids coils as a right handed screw with the side chains projecting outward from the coiled backbone.	• It is formed when the polypeptide chains are arranged side by side in a zig-zag manner with alternate —*R* groups on the same side.
• The coil is stabilized by intramolecular hydrogen bonds between carbonyl oxygen of first amino acid to amide nitrogen of fourth amino acid.	• It is stabilized by intermolecular hydrogen bonds between the carbonyl oxygens and amide hydrogens of two or more adjacent polypeptide chains.
• Such proteins are elastic, *i.e.*, they can be stretched.	• These sheets can slide over each other.
• *e.g.* myosin in nucleus and keratin in hair, wool, nails, claws, horns, feathers.	• *e.g.* silk fibroin is rich in β-pleated sheets.
• It is formed if —*R* groups are larger.	• It is formed if —*R* groups are smaller.
	

SELF CHECK

4. The secondary structure of a protein refers to
   (a) fixed configuration of the polypeptide backbone
   (b) α-helical backbone
   (c) hydrophobic interactions
   (d) sequence of α-amino acids.

(AIEEE 2007)

- **Tertiary structure of proteins:** It refers to the definite geometric pattern in which the entire protein molecule folds up in the three dimensional space to produce a specific shape.
  - Further folding, twisting and bending of secondary structure results in tertiary structure of proteins.
  - The bonds responsible for such interaction are as follows:
    - Hydrophobic interactions
    - Hydrogen bonds
    - Ionic interactions
    - van der Waals' forces
    - Disulphide bonds
  - These are of two types:
    - Tertiary structure of fibrous protein has same secondary (α-helix or β-pleated) structure throughout the length of the protein.
    - Tertiary structure of globular protein does not have the same secondary structure throughout the length of the molecule. Parts of the molecule may have α-helical structure, while the other part may have β-pleated sheet structure.
- **Quaternary structure of proteins:** Some of the proteins are composed of two or more polypeptide chains referred to as sub-units. The spatial arrangement of these sub-units with respect to each other is known as quaternary structure of proteins.
- **Denaturation of proteins:** It involves irreversible precipitation of proteins. The complex three dimensional structure of proteins changes by change in pH, temperature, presence of salts or certain chemical compounds.
  - Denaturation does not change primary structure but changes secondary and tertiary structures of proteins *e.g.*, coagulation of albumin present in white part of egg when egg is boiled.
  - It may be reversible or irreversible.

Enzymes

- The enzymes are biocatalysts produced by living cells which catalyse biochemical reactions in living organisms. Chemically, they are naturally occurring simple or conjugated proteins.
- **Properties**
  - Enzymes are needed in very small amount.
  - They reduce magnitude of activation energy.
  - They are highly specific.
  - They work at specific pH.
  - They work well at moderate temperature.
- **Importance**
  - They play a vital role in living organisms as they catalyse many biological processes.
  - Enzyme deficiency causes diseases *e.g.*, the deficiency of phenylalanine hydroxylase enzyme causes phenylketone urea (PKU) and the deficiency of tyrosinase causes albinism.
  - They are used for the production of beer, wine, syrup and cheese etc.

VITAMINS

- These are complex organic molecules which cannot be produced by the body and must be supplied in small amounts in diet to carry out essential metabolic reactions which are required for normal growth and maintenance of the body.
- **Classification**

Water soluble vitamins

- Soluble in water.
- Must be supplied regularly in diet as they are regularly excreted in urine (except vitamin B_{12}). *e.g.*, Vitamin - B_1, B_2, B_6, B_{12} and C

Fat soluble vitamins

- Soluble in fat and oils.
- Stored in liver and adipose tissues.

e.g., Vitamin - A, D, E and K

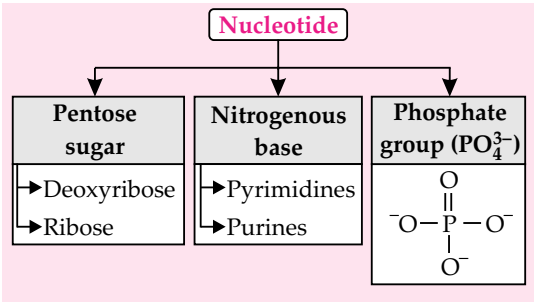
Vitamin name	Chemical name	Solubility	Sources	Deficiency disease
Vitamin A	Retinol or axerophthol	Fat	Milk, butter, eggs, fish, cod liver oil, green vegetables, etc.	Night-blindness, xerophthalmia
Vitamin B_1	Thiamine	Water	Pulses, nuts, cereals (rice, wheat, etc.), rice bran, yeast, egg yolk, fruits and green vegetables, etc.	Beri-beri, loss of appetite
Vitamin B_2	Riboflavin	Water	Milk, green vegetables, egg white, meat, liver, kidney, etc.	Inflammation of tongue, dermatitis, cheilosis
Vitamin B_6	Pyridoxine	Water	Rice bran, whole cereals (wheat, gram), yeast, fish, meat, eggs, etc.	Affects central nervous system, causes weakness, convulsions, insomnia and anaemia
Vitamin H	Biotin	None	Milk, yeast, liver, kidney, etc.	Dermatitis
Vitamin B_{12}	Cyanocobalamin	Water	Eggs, milk, liver of ox, sheep, fish, etc.	Pernicious anaemia
Vitamin C	Ascorbic acid	Water	Citrus fruits, chillies, sprouted pulses, etc.	Pyorrhea, scurvy (bleeding of gums)
Vitamin D (a mixture of vitamins D_1 and D_3)	Ergocalciferol and cholecalciferol	Fat	Butter, milk, eggs, fish liver oil, liver and meat (Vitamin D_3 is produced in skin in presence of sunlight).	Rickets (bending of bones) and osteomalacia
Vitamin E	Tocopherol	Fat	Wheat germ oil, milk, nuts, peanut oil, cotton seed oil, eggs, fish, etc.	Loss of fertility in males, muscle degeneration
Vitamin K	Phylloquinone	Fat	Leafy vegetables like cabbage, spinach, etc.	Haemorrhages and lengthens the time of blood clotting

KEY POINT

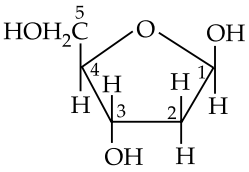
- Plants can synthesize all vitamins but only a few are synthesized in animals.
- Vitamin D is produced in the skin by the irradiation of ergosterol present in the body with ultraviolet light.
- Vitamin A is synthesized from carotenes.
- Vitamin B complex and vitamin K are synthesized by microorganisms present in the intestinal tract.

NUCLEIC ACIDS

- Nucleic acids are complex compounds of carbon, hydrogen, oxygen, nitrogen and phosphorus.
  - They play an essential role in transmission of the hereditary characteristics and biosynthesis of proteins.
- They are polynucleotides.
  - Nucleotides are composed of three parts; pentose sugar, nitrogenous base and phosphate group.

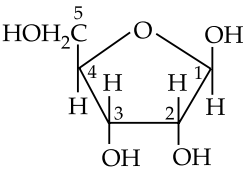


- **Pentose sugar**
  - *Deoxyribose:*



β-*D*-2-Deoxyribose

  - *Ribose:*

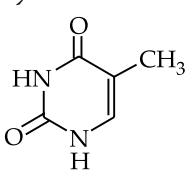


β-*D*-Ribose

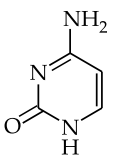
KEY POINT

- Both *D*-ribose and *D*-2-deoxyribose differ only at C-2 atom in the ring.

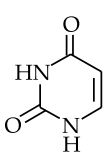
- **Nitrogenous base:** These are heterocyclic organic compounds having two or more nitrogen atoms in the ring.
  - *Pyrimidine derivatives:*



Thymine (T)

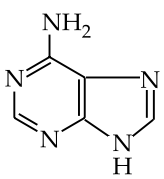


Cytosine (C)

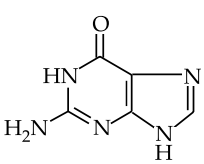


Uracil (U)

  - *Purine derivatives:*



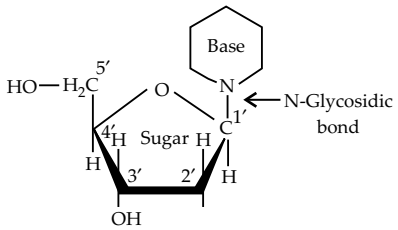
Adenine (A)



Guanine (G)

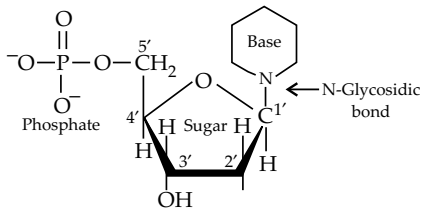
Structure

- Nucleoside is formed by condensation of a base with sugar at C-1′ position.



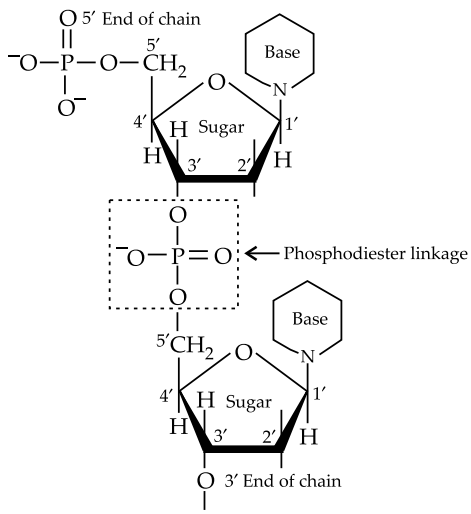
Base-Sugar linkage

- Nucleotide is formed when nucleoside is linked to phosphoric acid at C-5′ position of sugar moiety.



Phosphate-Sugar-Base linkage

- Nucleic acid is formed when nucleotides are joined together by phosphodiester linkages between 5′ and 3′ carbon atoms of pentose sugar.



- Two types of nucleic acids, *viz*, DNA and RNA are distinguished from each other in the following manner:

Deoxyribonucleic acid (DNA)	Components	Ribonucleic acid (RNA)
2-deoxy-*D*-(–) ribose	**Sugar**	*D*-(–) ribose
Cytosine and thymine	**Pyrimidine base**	Uracil and cytosine
Adenine and guanine	**Purine base**	Adenine and guanine
H_3PO_4	**Phosphoric acid**	H_3PO_4
Double stranded α-helix	**Structure**	Single stranded α-helix
Possible	**Replication**	Not possible

- **Primary structure of nucleic acid:** It involves the combination of thousands of molecules of nucleotides with the elimination of water molecules.
- **Secondary structure of nucleic acid:**
  - Secondary structure of DNA consists of two polynucleotide chains, twisted about a common axis, but run in opposite direction to form a right handed helix.
    - The two chains are joined together by specific hydrogen bonds A(Adenine) to T(Thymine) and G(Guanine) to C(Cytosine).
    - Approximately there are ten nucleotide units in one turn of each strand and the backbone (consisting of 2-deoxyribose and phosphate units) of each nucleotide lies outside the helix of each strand, while the nitrogen bases in each strand lie in the centre of the helix.
  - In secondary structure of RNA, helices are present which are only single stranded. Sometimes they fold back on themselves to form a double helix structure.
- **Chargaff's rule:** Amount of purine bases is always equal to that of pyrimidine bases.
  - Purine base of one strand of DNA molecule pairs with pyrimidine base of the other strand.
  - Adenine (A) pairs with thymine (T) through two H-bonds (A═T) and guanine (G) pairs with cytosine (C) through three H-bonds (G≡C).
  - In case of RNA, adenine (A) pairs with uracil (U), (A═U).
- Nucleic acids have two main functions:
  1. Replication 2. Protein synthesis

SELF CHECK

5. Which one of the following bases is not present in DNA?
   (a) Thymine (b) Quinoline
   (c) Adenine (d) Cytosine
   (JEE Main 2014)
6. The presence or absence of hydroxy group on which carbon atom of sugar differentiates RNA and DNA?
   (a) 1^{st} (b) 2^{nd}
   (c) 3^{rd} (d) 4^{th}
   (AIEEE 2011)
7. In both DNA and RNA, heterocyclic base and phosphate ester linkages are at
   (a) C_5' and C_2' respectively of the sugar molecule
   (b) C_2' and C_5' respectively of the sugar molecule
   (c) C_1' and C_5' respectively of the sugar molecule
   (d) C_5' and C_1' respectively of the sugar molecule.
   (AIEEE 2005)
8. The pyrimidine bases present in DNA are
   (a) cytosine and adenine
   (b) cytosine and guanine
   (c) cytosine and thymine
   (d) cytosine and uracil.
   (AIEEE 2006)

KEY POINT

- Mutation is a chemical or physical change that alters the sequence of bases in DNA strands that can lead to the synthesis of proteins with altered α-amino acid sequence.
- These mutations often prove harmful and give rise to symptoms that cause diseases.

POLYMERS

- Classification of Polymers
- Methods of Polymerization
- Copolymerization
- Rubber
- Some Important Polymers

TIPS TO REMEMBER

- Polymers are the macromolecules, which are formed by joining of repeating structural units known as monomers and are linked to each other by covalent bonds. This process is called polymerization.
- There are two types of polymers, homopolymers (only one type of monomers) and copolymers (two or more types of monomers).

CLASSIFICATION OF POLYMERS

- It depends on source, structure, mode of polymerization, molecular forces and type of mechanism involved during the growth of polymerization chain.
  - On the basis of source, they are natural, synthetic and semi-synthetic polymers.
  - On the basis of structure, they are linear, branched chain and cross-linked polymers.
  - On the basis of mode of polymerization, they are addition and condensation polymers.
  - On the basis of molecular forces, they are elastomers, fibres, thermoplastic and thermosetting polymers.
  - On the basis of type of mechanism involved during the growth of polymerization chain, they are chain growth and step growth polymers.

METHODS OF POLYMERIZATION

- **Chain growth addition polymerization**
  - It involves a series of reactions each of which consumes a reactive particle and produces another similar one. The reactive particles may be free radicals or ions (cations or anions) to which monomers (alkenes or conjugated dienes) get added by a chain reaction.
  - Depending upon the reactive particles formed, it is further divided into three types:
    - Free radical polymerization
    - Cationic polymerization
    - Anionic polymerization
  - **Free radical polymerization**
    - Initiators which generate free radicals on heating are dioxygen, benzoyl peroxide, acetyl peroxide, *tert*-butyl peroxide.
    - Free radical thus formed adds to the double bond of monomer and forms a new and large free radical. This step is chain initiating step.
    - Repetition of this step with new and larger radicals is called chain propagating step.
    - The growing free radical chain gets terminated by reactions which consume these free radicals either by combination or by disproportion to get polymer is called chain termination step.
  - **Cationic polymerization**
    - Monomers with electron donating substituents are polymerized by a cationic polymerization initiated by strong Lewis acids such as BF_3, $AlCl_3$, H_2SO_4 etc. in presence of a trace of water as initiator.

      $H_2SO_4 \longrightarrow H^+ + HSO_4^-$

      $H^+ + CH_2 = CH_2 \longrightarrow \underset{\text{Carbocation}}{CH_3 - CH_2^+}$
  - **Anionic polymerization**
    - Monomers with electron withdrawing substituents are polymerized by an anionic polymerization initiated by strong bases such as Na, KNH_2 or organometallic compounds.

      $B: + CH_2 = CH_2 \longrightarrow \underset{\text{Carbanion}}{B - CH_2 - CH_2^-}$

SELF CHECK

9. The species which can best serve as an initiator for the cationic polymerization is
   (a) HNO_3 (b) $AlCl_3$
   (c) BuLi (d) $LiAlH_4$
   (AIEEE 2012)

- **Step growth condensation polymerization**
  - In this type of polymerization reactions, monomers are bifunctional and form bond with the loss of simple molecule of water, alcohol, ammonia, etc.
  - The dimer formed, also contains two functional groups , thus undergoes a series of condensations in a stepwise manner and results in the formation of a high molecular mass condensation polymer.

COPOLYMERIZATION

- When two or more different monomers unite together to polymerize, the resulting product is called a copolymer and the process is termed as copolymerization.
  - The properties of a copolymer are entirely different from a physical mixture of the two individual polymers. Copolymers have better physical and mechanical properties.
  - The properties could be changed by varying the amounts of each monomer.

RUBBER

- It is of two types:
  - **Natural rubber**
    - It is obtained as latex from rubber tree.
    - It is highly elastic.
    - It is *cis*-1,4-polyisoprene.
    - All *trans* configuration occurs naturally as gutta-percha, which is non-elastic.
  - **Synthetic rubber**
    - It is obtained by polymerizing certain organic compounds which may have properties similar to rubber and some additional desirable properties.
    - Most of these polymers are derived from butadiene derivatives. For example, neoprene, buna-S, buna-N, thiokol, silicones, polyurethane rubber.

Vulcanization of Rubber

- Vulcanization is a process of treating natural rubber with sulphur and an appropriate additive at a temperature range of 373 to 415 K, to modify its properties. On vulcanization sulphur forms cross-links at the reactive sites of the double bonds and gives mechanical strength to the rubber.
- The extent of hardness or toughness, however, depends upon the amount of sulphur added. Thus, about 5% sulphur is used for making tyre rubber, 20-25% sulphur for making ebonite and 30% sulphur for making battery case rubber.

KEY POINT

- Number average molecular mass

$$(\bar{M}_n) = \frac{\Sigma N_i M_i}{\Sigma N_i}$$

- Weight (mass) average molecular mass

$$(\bar{M}_w) = \frac{\Sigma N_i M_i^2}{\Sigma N_i M_i}$$

- Polydispersity Index (PDI) $= \frac{\bar{M}_w}{\bar{M}_n}$
- Polymers which are produced by biological systems such as microorganisms, plants and animals and are essential for life are biopolymers.
- They can also be synthesized chemically. *e.g.*, starch, cellulose, proteins, nucleic acids, PHBV etc.
- They are biodegradable *e.g.*, PHBV, poly (glycollic acid) poly (lactic acid) and nylon-2-nylon-6.

SOME IMPORTANT POLYMERS

Preparation of Addition Homopolymers

❑ Polyolefins

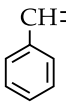
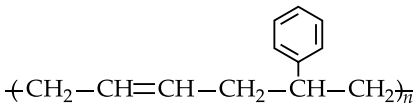
Polymer	Structure of monomer	Structure of polymer
Polythene	$CH_2 = CH_2$ Ethylene	$-(CH_2-CH_2)_n-$
Polypropylene	$CH_3-CH = CH_2$ Propylene	$\left(\begin{array}{l}CH_3\\ \vert\\ CH-CH_2\end{array}\right)_n$
Polytetrafluoroethene (Teflon) (PTFE)	$CF_2 = CF_2$ Tetrafluoroethene	$-(CF_2-CF_2)_n-$
Polyacrylonitrile (Orlon) (PAN)	$CH_2 = CHCN$ Acrylonitrile (Vinyl cyanide)	$\left(\begin{array}{l}CN\\ \vert\\ CH_2-CH\end{array}\right)_n$
Polyvinyl chloride (PVC)	$CH_2 = CHCl$ Chloroethene (Vinyl chloride)	$\left(\begin{array}{l}Cl\\ \vert\\ CH_2-CH\end{array}\right)_n$
Polystyrene (Styron)	$CH_2=CH$ 	$\left[CH_2-CH\right]_n$ 
Polymethylmethacrylate (PMMA)	$CH_2=\underset{\vert}{\overset{CH_3}{C}}-COOCH_3$ Methylmethacrylate	$\left(\begin{array}{l}H_3C\\ \vert\\ CH_2-C\\ \vert\\ COOCH_3\end{array}\right)_n$
Polymonochlorotrifluoroethylene (PCTFE)	$Cl-\underset{\vert}{\overset{F}{C}}=CF_2$ Chlorotrifluoroethylene	$\left(\begin{array}{l}Cl\\ \vert\\ C-CF_2\\ \vert\\ F\end{array}\right)_n$

❑ Polydienes

Polymer	Structure of monomer	Structure of polymer
Natural rubber	$CH_2=\underset{\vert}{\overset{CH_3}{C}}-CH=CH_2$ Isoprene (2-Methyl-1, 3-butadiene)	$\left(\begin{array}{l}CH_3\\ \vert\\ CH_2-C=CH-CH_2\end{array}\right)_n$ *cis*-1, 4-Polyisoprene
Neoprene (synthetic rubber)	$CH_2=\underset{\vert}{\overset{Cl}{C}}-CH=CH_2$ Chloroprene (2-Chloro-1, 3-butadiene)	$\left(\begin{array}{l}Cl\\ \vert\\ CH_2-C=CH-CH_2\end{array}\right)_n$
Gutta-percha	$CH_2=\underset{\vert}{\overset{CH_3}{C}}-CH=CH_2$ Isoprene (2-Methyl-1, 3-butadiene)	$\left(\begin{array}{l}CH_3\\ \vert\\ CH_2-C=CH-CH_2\end{array}\right)_n$ *trans*-Polyisoprene

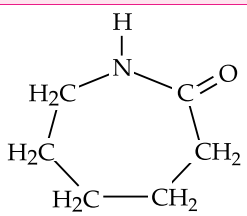
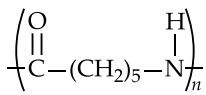
Preparation of Addition Copolymers

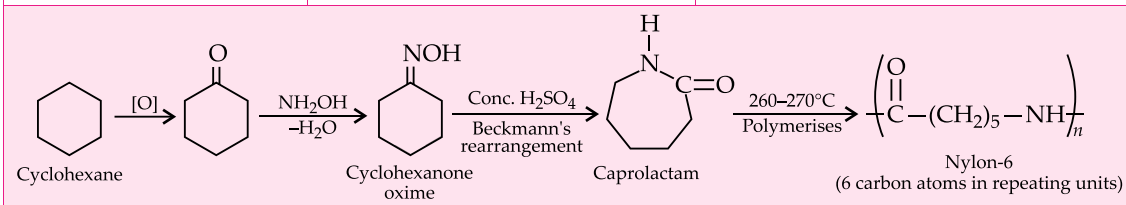
❑ Polydienes

Polymer	Structure of monomer	Structure of polymer
Buna-S (Styrene Butadiene Rubber) (SBR)	$CH_2=CH-CH=CH_2$ 1, 3-Butadiene  Styrene	
Buna-N (Nitrile rubber)	$CH_2=CH-CH=CH_2$ 1,3-Butadiene $CH_2=CH-CN$ Acrylonitrile	

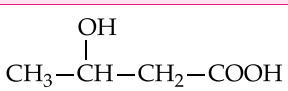
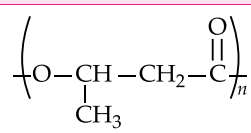
Preparation of Condensation Homopolymers

❑ Polyamides

Polymer	Structure of monomer	Structure of polymer
Nylon-6 (Perlon-L)	 Caprolactam	



❑ Polyesters

Polymer	Structure of monomer	Structure of polymer
Polyhydroxybutyrate (PHB)	 3-Hydroxybutanoic acid	

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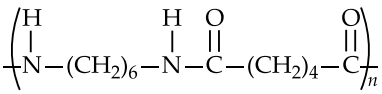
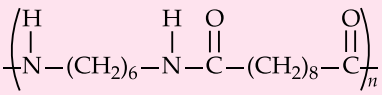
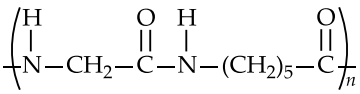
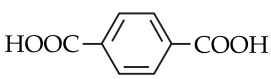
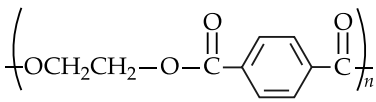
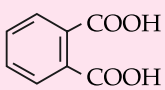
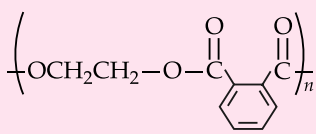
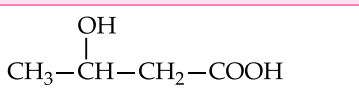
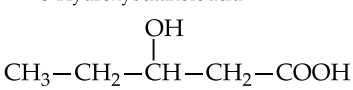
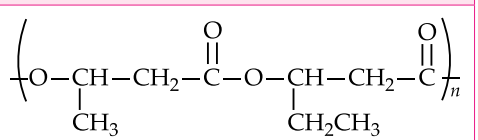
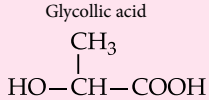
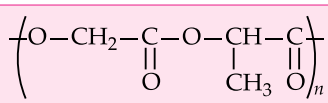
Preparation of Condensation Copolymers

❑ Polyamides

Polymer	Structure of monomer	Structure of polymer
Nylon-6,6	$HOOC-(CH_2)_4-COOH$ Adipic acid $H_2N-(CH_2)_6-NH_2$ Hexamethylenediamine	
Nylon-6, 10	$HOOC-(CH_2)_8-COOH$ Sebacic acid $H_2N-(CH_2)_6-NH_2$ Hexamethylenediamine	
Nylon-2, 6	H_2N-CH_2-COOH Glycine $H_2N-(CH_2)_5-COOH$ 6-Aminohexanoic acid	

❑ Polyesters

Polymer	Structure of monomer	Structure of polymer
Terylene (Dacron)	$HOCH_2-CH_2OH$ Ethylene glycol (Ethane-1,2-diol)  Terephthalic acid (Benzene-1, 4-dicarboxylic acid)	
Glyptal (Alkyd resin)	$HOCH_2-CH_2OH$ Ethylene glycol  Phthalic acid (Benzene-1,2-dicarboxylic acid)	
Poly β-hydroxy butyrate-co-β-hydroxy valeratre (PHBV)	 3-Hydroxybutanoic acid  3-Hydroxypentanoic acid	
Poly(glycollic acid) poly(lactic acid) (Dextron)	$HO-CH_2-COOH$ Glycollic acid  Lactic acid	

CONCEPT MAP

SURFACE CHEMISTRY

(Branch of chemistry which deals with the phenomena occurring at the surface or interface.)

Adsorption

Definition and Properties

- The accumulation of molecular species at the surface rather than in the bulk of a solid or liquid.
- Surface phenomena.
- Spontaneous, exothermic and leads to lowering of entropy.

Terminology

- **Adsorbate :** Substance adsorbed.
- **Adsorbent :** Substance on the surface of which adsorbate is adsorbed.
- **Desorption :** Reverse of adsorption.
- **Occlusion :** Adsorption of gases on the surface of metals.
- **Sorption :** Adsorption and absorption take place simultaneously.

Types

Physisorption

- Molecules are held by weak van der Waals forces.
- Low heat of adsorption and non specific.
- No compound is formed.
- Decreases with increase in temperature.
- Forms multimolecular layer and is reversible.

Chemisorption

- Molecules are held by strong chemical bonds.
- High heat of adsorption and specific.
- Surface compounds are formed.
- Increases with increase in temperature.
- Forms unimolecular layer and is irreversible.

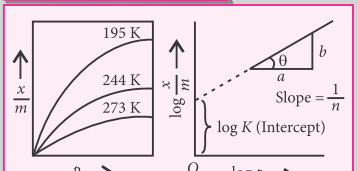
Positive adsorption

- Concentration of the adsorbate is more on the surface of the adsorbent than in the bulk.

Negative adsorption

- Concentration of the adsorbate increases in the bulk after adsorption.

Adsorption Isotherms



Adsorption isotherm | Freundlich isotherm

Catalysis

Definition

- The phenomenon of enhancing the rate of a chemical reaction by using a catalyst.

Terminology

- **Promoters :** Substances that enhance the activity of a catalyst.
- **Poisons :** Substances which decrease the activity of a catalyst.
- **Activity :** Capacity to increase the speed of the chemical reaction.
- **Selectivity :** Ability of a catalyst to direct the reaction to yield a particular product.

Types

Homogeneous catalysis : When the reactants and catalyst are in the same phase *e.g.*, oxidation of SO_2 to SO_3 in presence of NO as catalyst (lead chamber process).

Heterogeneous catalysis : When the reactants and catalyst are in different phases *e.g.*, manufacture of NH_3 from N_2 and H_2 using Fe as catalyst. (Haber's process).

Autocatalysis : One of the products formed itself acts as a catalyst *e.g.*, titration of oxalic acid with $KMnO_4$ in presence of dil. H_2SO_4.

Induced catalysis : One reaction influences the rate of other reaction, which does not occur under ordinary conditions *e.g.*, oxidation of sodium arsenite is induced by oxidation of sodium sulphite.

Positive catalysis : Catalyst increases the speed of a reaction.

Negative catalysis : Catalyst decreases the speed of a reaction.

Shape–Selective Catalysis

- Depends upon the pore structure of catalyst and size of reactant and product molecules.
- Zeolites are good shape-selective catalysts due to honey comb-like structures.

Enzymes

- Biocatalysts
- Highly efficient and specific in nature.
- Highly active under optimum temperature and pH.
- Activity increases in the presence of activators and co-enzymes.
- Activity inhibited by inhibitors and poisons.

Colloids

Definition

- A heterogeneous system in which particle size is between 1 and 1000 nm.

Terminology

- **Dispersed phase :** Substance which is dispersed. It is a discontinuous phase.
- **Dispersion medium :** Medium in which the substance is dispersed. It is a continuous phase.

Classification

Based on physical state of dispersed phase and dispersion medium :

- **Sols :** Solids in liquids *e.g.*, paints
- **Gels :** Liquids in solids *e.g.*, cheese
- **Emulsions :** Liquids in liquids.
  - Oil in water type emulsions *e.g.*, milk.
  - Water in oil type emulsions *e.g.*, butter.

Based on nature of interaction between dispersed phase and dispersion medium :

- **Lyophilic colloids :** Liquid-loving, directly formed, reversible in nature, quite stable, cannot be easily coagulated.
- **Lyophobic colloids :** Liquid-hating, prepared by special methods, readily coagulated, irreversible, not stable, and need stabilising agents for their preservation.

Based on type of particles of the dispersed phase :

- **Multimolecular colloids :** Formed by aggregation of a large number of atoms or molecules (diameter < 1 nm) held by weak van der Waals forces.
- **Macromolecular colloids :** Formed by molecules of large size.
- **Associated colloids :** Formed by substances which at low concentrations behave as normal strong electrolytes, but at higher concentrations exhibit colloidal behaviour due to the formation of aggregates (called micelles).

Important Processes and Properties

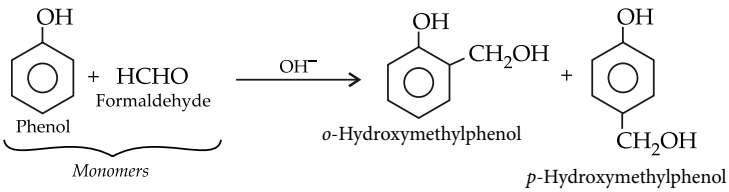
- **Tyndall effect :** Scattering of light by the colloidal particles.
- **Brownian movement :** Continuous zig-zag movement of colloidal particles.
- **Peptization :** Converting a precipitate into colloidal sol by shaking it with dispersion medium in the presence of a small amount of electrolyte.
- **Dialysis :** Separation of colloidal particles from crystalloids by diffusion through a parchment or an animal membrane.
- **Ultrafiltration :** Separation of colloidal particles from crystalloids by filtration using ultrafilter papers.
- **Coagulation :** Settling of colloidal particles.
- **Zeta potential :** Potential difference between the fixed layer and the diffused layer of opposite charges, also called electrokinetic potential.

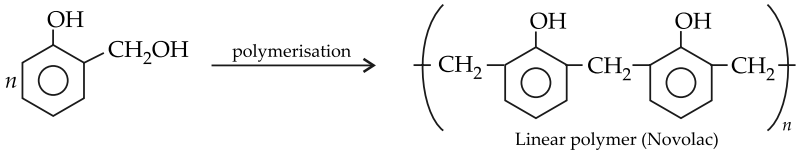
Have a Look!

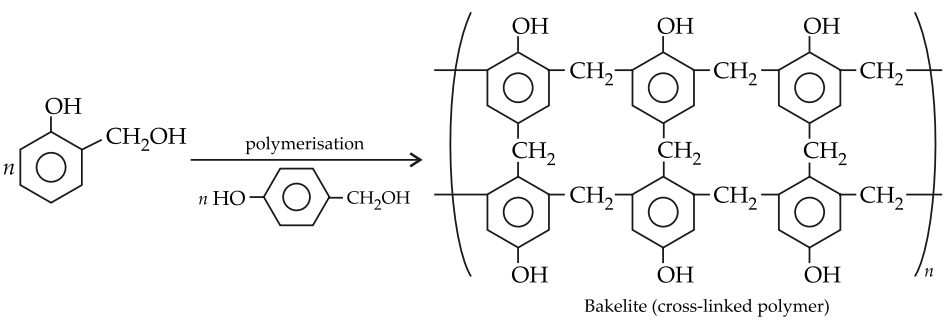
- Higher the critical temperature of a gas, more strongly it is adsorbed.
- A more strongly adsorbable substance can displace a weakly adsorbed substance from the surface of the adsorbent.
- The minimum amount of an electrolyte (millimoles) that must be added to one litre of a colloidal solution for complete coagulation is called the *coagulation* or *flocculation* or *precipitation* value of the electrolyte and smaller the value, greater is its coagulating power.
- According to Hardy-Schulze rule, greater the valency of the flocculating ion added, greater is its power to cause precipitation.

❑ Formaldehyde resins

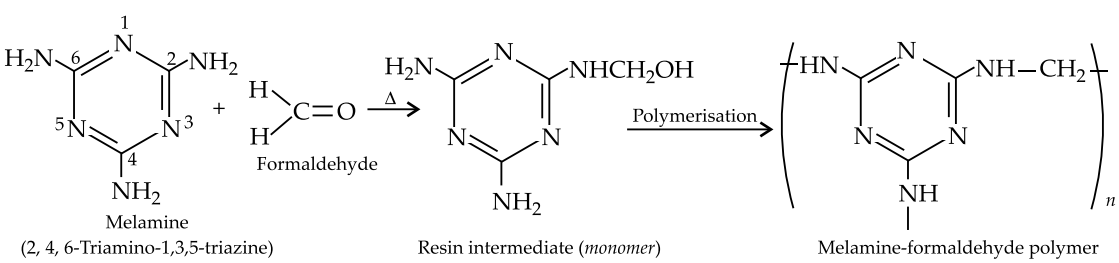
Phenol-formaldehyde resin (Bakelite)



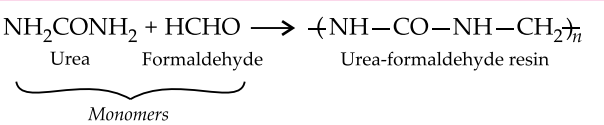




Melamine-formaldehyde resin (Melmac)



Urea-formaldehyde resin



❑ Polysulphide

Thiokol $-[-CH_2CH_2-S-S-S-S-]_n-$	$Cl-CH_2CH_2-Cl$ Ethylene dichloride Na_2S_4 Sodium tetrasulphide

SELF CHECK

10. Which one is classified as a condensation polymer?
    (a) Acrylonitrile (b) Dacron
    (c) Neoprene (d) Teflon
    (JEE Main 2014)

11. Buna-N synthetic rubber is a copolymer of
    (a) $H_2C=CH-\underset{\underset{Cl}{|}}{C}=CH_2$ and $H_2C=CH-CH=CH_2$
    (b) $H_2C=CH-CH=CH_2$ and $H_5C_6-CH=CH_2$
    (c) $H_2C=CH-CN$ and $H_2C=CH-CH=CH_2$
    (d) $H_2C=CH-CN$ and $H_2C=CH-\underset{\underset{Cl}{|}}{C}=CH_2$
    (AIEEE 2009)

12. Which of the following is fully fluorinated polymer?
    (a) Neoprene (b) Teflon
    (c) Thiokol (d) PVC
    (AIEEE 2005)

CHEMISTRY IN EVERYDAY LIFE

- Chemicals in Medicines
- Chemicals in Food
- Cleansing Agents

TIPS TO REMEMBER

CHEMICALS IN MEDICINES

- Drugs are low molecular mass chemicals which interact with macromolecular targets and produce a biological response. When the biological response is therapeutic and useful, these chemicals are called medicines.
- Use of chemicals for therapeutic effect is called chemotherapy.

Antacids Drugs which reduce or neutralise acidity. *e.g.* baking soda, metal hydroxides like $Al(OH)_3$, $Mg(OH)_2$, cimetidine, ranitidine, lansoprazole, omeprazole.

Antihistamines Drugs which are used for the treatment of allergies. *e.g.* diphenylhydramine (benadryl), pheniramine maleate (avil), chlorpheniramine (zeet).

Antiseptics Drugs which are applied to the living tissues such as wounds, cuts, ulcers and diseased skin surfaces. *e.g.* furacin, soframycin, dettol.

Analgesics Drugs which relieve pain.
Non-narcotics: aspirin, paracetamol.
Narcotics: morphine, codeine.

Tranquillizers Drugs which are used for the treatment of stress, fatigue, mild and severe mental diseases.
Narcotics: Heroin, pethidine.
Sedatives: Valium, barbiturates.
Antidepressants: Iproniazid, phenelzine.
Hypnotics: Seconal, luminal, veronal.
Non-hypnotics: Equanil, meprobamate, chlorodiazepoxide.

Antifertility Drugs Drugs which are used to reduce birth rates. *e.g.* mifepristone.

Disinfectants Drugs which kill or stop the growth of microorganisms, but are harmful to living cells *e.g.* 1% solution of phenol, bleaching powder, H_2O_2.

Antipyretics Drugs which are used to bring down the body temperature during high fever.
e.g. aspirin, phenacetin and paracetamol.

Antimicrobials Drugs which inhibit the action or growth of microbes. *e.g.* antibiotics, antiseptics and disinfectants..

Antibiotics Drugs which are produced by living cells and capable of inhibiting the life processes of micro-organisms. *e.g.* penicillin, erythromycin, tetracycline, etc.

KEY POINT

- Anaesthetics are the drugs which produce insensibility to the vital functions of all types of cells especially of nervous system. *e.g.* sodium pentothal.

SELF CHECK

13. Aspirin in known as
    (a) phenyl salicylate
    (b) acetyl salicylate
    (c) methyl salicylic acid
    (d) acetyl salicylic acid.

(AIEEE 2012)

14. Which one of the following types of drugs reduces fever?
    (a) Analgesic (b) Antipyretic
    (c) Antibiotic (d) Tranquilizer

(AIEEE 2005)

CHEMICALS IN FOOD

- Chemicals which are added to food to improve its keeping qualities, appearance, taste, odour and nutritive (food) value are called food additives.

Food Preservatives

- Compounds which are used to protect food against bacteria, yeasts and moulds. *e.g.* table salt, sugar, citric acid, sodium benzoate, salts of propionic acid, sorbic acid.

Artificial Sweetening Agents

- Compounds which give sweetening effect and enhance colour and flavour of food. *e.g.* saccharin, aspartame, alitame.

Antioxidants

- Compounds which are used to prevent oxidation of fats in processed foods such as potato chips, biscuits, breakfast cereals, crackers, etc. *e.g.* butylated hydroxy anisole (BHA) and butylated hydroxy toluene (BHT).

CLEANSING AGENTS

Soaps

- They are the sodium or potassium salts of saturated and unsaturated long chain carboxylic acids containing 12 to 18 carbon atoms (fatty acids). *e.g.* salts of $C_{15}H_{31}COOH$ (palmitic acid), $C_{17}H_{35}COOH$ (stearic acid), $C_{17}H_{33}COOH$ (oleic acid), $C_{17}H_{31}COOH$ (linoleic acid), etc.

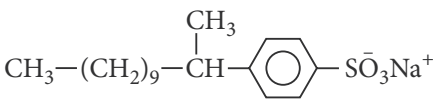
Synthetic Detergents

- They are the sodium salts of long chain alkyl hydrogen sulphates or the sodium salts of long chain benzene sulphonic acids.
- **Classification of detergents**
  - **Anionic detergents:** These are of two types:
    - **Alkyl hydrogen sulphates**

$$CH_3(CH_2)_{10}CH_2OSO_3^-Na^+$$

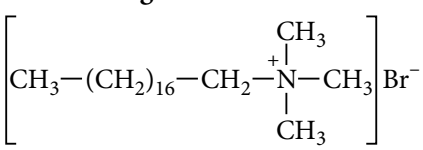
Sodium laurylsulphate

    - **Sodium alkyl benzene sulphonates**

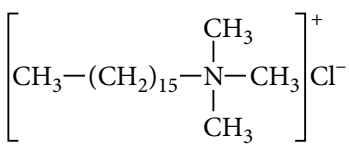


Sodium-2-dodecylbenzene sulphonate (SDS)

  - **Cationic detergents:**



Trimethylstearylammonium bromide



Cetyltrimethylammonium chloride

  - **Non-ionic detergents:**

$$CH_3(CH_2)_{10}CH_2(OCH_2CH_2)_8OH$$

Lauryl alcohol ethoxylate

$$CH_3(CH_2)_{16}COO(CH_2CH_2O)_nCH_2CH_2OH$$

Polyethyleneglycol stearate

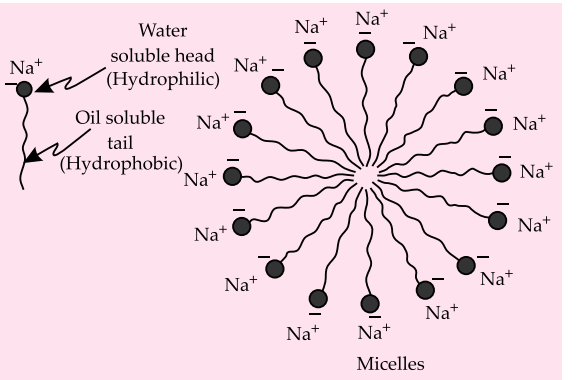
Advantages of Synthetic Detergents over Soaps

- These can be used both in soft and hard water whereas ordinary soaps cannot be used in hard water.
- The aqueous solution of detergents are neutral and hence, can be used for washing all types of fabrics without any damage. The solution of ordinary soap is alkaline and thus, cannot be used to wash delicate fabrics.

- These can be used even in acidic medium as they are salts of strong acids and are not decomposed in acidic medium whereas soaps are decomposed into carboxylic acids in acidic medium.

Cleansing Action of Soaps and Detergents

- The organic part of a natural soap (polar molecule) is negatively charged.
  - Its hydrophilic (water loving) carboxylate group ($—COO^-$) interacts with water molecules via ion-dipole interactions and hydrogen bonding.
  - The hydrophobic (water-repelling) part of a soap molecule which is long, non-polar hydrocarbon chain, does not interact with water molecules.
  - The hydrocarbon chains are attracted to each other by dispersion forces and cluster together, forming structures called micelles.
    - In these micelles, the carboxylate groups form a negatively charged spherical surface, with the hydrocarbon chains inside the sphere.
    - Because they are negatively charged, soap micelles repel each other and remain dispersed in water.



ANSWER KEYS (SELF CHECK)

1. (d)	**2.** (d)	**3.** (b)	**4.** (b)	**5.** (b)
6. (b)	**7.** (c)	**8.** (c)	**9.** (b)	**10.** (b)
11. (c)	**12.** (b)	**13.** (d)	**14.** (b)	

Exam Café

QUESTIONS FOR PRACTICE

1. Which of the following is correct statement?
(a) Starch is a polymer of α-*D*-glucose.
(b) Amylose is a component of cellulose.
(c) Proteins are composed of only one type of amino acid.
(d) In cyclic structure of fructose, there are four carbons and one oxygen atom.

2. Natural rubber and gutta-percha respectively are
(a) *trans*-polychloroprene and *cis*-polychloroprene
(b) both are *cis*-polyisoprene
(c) both are *trans*-polyisoprene
(d) *cis*-polyisoprene and *trans*-polyisoprene.

3. Which set has different class of compounds?
(a) Tranquillizers : equanil, heroin, valium
(b) Antiseptics : bithional, dettol, boric acid
(c) Analgesics : naproxen, morphine, aspirin
(d) Bactericidal : penicillin, aminoglycosides, ofloxacin

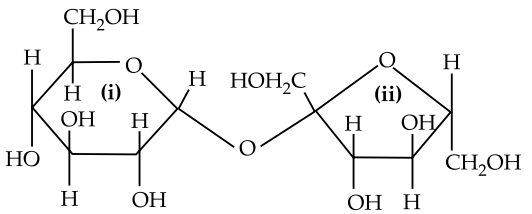
4. Which of the following amino acids is basic in nature?
(a) Glutamine (b) Arginine
(c) Serine (d) None of these

5. Consider the following polymers :
I. Polystyrene II. Dacron
III. Orlon
They are classified as

	I	II	III
(a)	chain-growth	step-growth	step-growth
(b)	chain-growth	chain-growth	step-growth
(c)	chain-growth	step-growth	chain-growth
(d)	step-growth	step-growth	chain-growth

6. Which of the following is not used as an antacid?
   (a) Magnesium hydroxide
   (b) Sodium carbonate
   (c) Sodium bicarbonate
   (d) Aluminium phosphate

7. The correct statement about the following disaccharide is

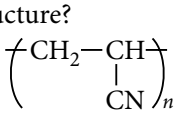
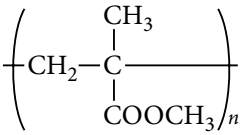
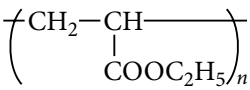
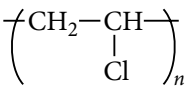


   (a) Ring (i) is pyranose with α-glycosidic linkage.
   (b) Ring (i) is furanose with α-glycosidic linkage.
   (c) Ring (ii) is furanose with α-glycosidic linkage.
   (d) Ring (ii) is pyranose with β-glycosidic linkage.

8. Monomer of orlon is
   (a) $H_2C=CH-Cl$
   (b) $H_2C=CH-C\equiv N$
   (c) $H_2C=CH-OCOCH_3$
   (d) $F_2C=CF_2$

9. Which of the following possess germicidal properties?
   (a) Cationic detergents
   (b) Anionic detergents
   (c) Non-ionic detergents
   (d) None of these

10. Two isomeric sugars that are cyclic and only differ in the position of the —OH group at the glycosidic carbon are called
   (a) enantiomers (b) mutarotators
   (c) anomers (d) epimers.

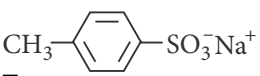
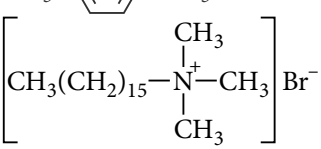
11. Acrilan is a hard, horny and high melting material. Which of the following represents its structure?
   (a) 
   (b) 
   (c) 
   (d) 

12. Choose the correct statement.
   (a) Saccharin is 650 times sweeter than sugar.
   (b) Aspartame is 550 times sweeter than sugar.
   (c) Sucralose is 160 times sweeter than sugar.
   (d) Alitame is 2000 times sweeter than sugar.

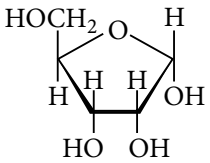
13. Consider the following statements about sucrose :
   I. Hydrolysis of sucrose with dilute acid yields an equimolar mixture of *D*-glucose and *D*-fructose.
   II. Acid hydrolysis of sucrose is accompanied by a change in optical rotation.
   III. In sucrose, the glycosidic linkage is between C_1 of glucose and C_2 of fructose.
   IV. Aqueous solution of sucrose exhibits mutarotation.

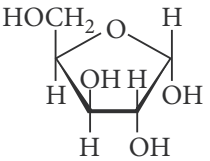
   Which of the statements given above are correct?
   (a) I, II and III (b) I and IV
   (c) II, III and IV (d) II and IV

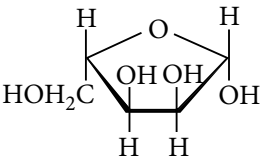
14. The best way to prepare polyisobutylene is through
   (a) coordination polymerisation
   (b) cationic polymerisation
   (c) anionic polymerisation
   (d) free radical polymerisation.

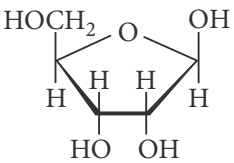
15. Which of the following is an example of liquid dishwashing detergent?
   (a) $CH_3(CH_2)_{10}CH_2OSO_3^-Na^+$
   (b) $CH_3(CH_2)_{16}COO(CH_2CH_2O)_nCH_2CH_2OH$
   (c) 
   (d) 

16. Which of the following represents the anomer of the compound shown?



(a) 

(b) 

(c) 

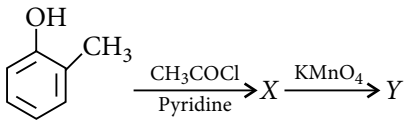
(d) None of these

17. Arrange the given polymers in increasing order of their intermolecular forces.
A = Nylon-6; *B* = Neoprene; *C* = PVC
(a) $A < B < C$ (b) $C < B < A$
(c) $B < C < A$ (d) $A < C < B$

18. An antibiotic contains nitro group attached to aromatic nucleus in its structure. It is
(a) penicillin (b) streptomycin
(c) tetracycline (d) chloramphenicol.

19. Two samples of DNA, I and II have melting points 340 K and 350 K respectively. This is because
(a) II has more GC content than I
(b) I has more GC content than II
(c) II has more AT content than I
(d) both have same AT content.

20. Arrange the following monomers in order of decreasing ability to undergo cationic polymerisation.
I. $CH_2=CH-C_6H_4(NO_2)$
II. $CH_2=CH-C_6H_4(CH_3)$
III. $CH_2=CH-C_6H_4(OCH_3)$
(a) I > II > III (b) III > II > I
(c) II > I > III (d) I > III > II

21. 

The final product *Y* is a medicine. Which of the following is incorrect regarding *Y*?
(a) It has analgesic as well as antipyretic properties.
(b) It helps to prevent heart attack.
(c) It has anti-blood clotting action.
(d) It suppresses the gastric anomalies.

22. Periodic acid splits glucose and fructose into formic acid and formaldehyde. Ratio of formic acid to formaldehyde obtained from glucose and fructose respectively are
(a) 4/2 and 4/2 (b) 5/1 and 5/1
(c) 5/1 and 3/2 (d) none of these.

23. Which of the following pairs of monomers form biodegradable polymer?
I. 3-Hydroxybutanoic acid + 3-hydroxypentanoic acid
II. Glycine + ε-aminocaproic acid
III. Ethylene glycol + phthalic acid
IV. Caprolactam
(a) I, II only (b) II, III only
(c) I, II and III only (d) II, III and IV only

24. Which of the following drug combinations is not correct?
(a) Phenacetin-antipyretic
(b) Chloramphenicol-broad spectrum antibiotic
(c) Equanil-sedative
(d) Bithional-tranquillizer

25. Which of the following is not an α-amino acid?
(a) Cysteine (b) Proline
(c) Trypsin (d) Serine

26. Match the polymers given in Column I with their commercial names given in Column II.

Column I		Column II	
A.	Polyester of ethylene glycol and phthalic acid	1.	Novolac
B.	Copolymer of 1,3-butadiene and styrene	2.	Glyptal
C.	Phenol and formaldehyde resin	3.	Buna-S
D.	Polyester of ethylene glycol and terephthalic acid	4.	Buna-N
E.	Copolymer of 1,3-butadiene and acrylonitrile	5.	Dacron

	A	B	C	D	E
(a)	4	3	2	1	5
(b)	2	3	1	5	4
(c)	2	1	3	4	5
(d)	2	1	3	5	4

27. Salol can be used as an
(a) antiseptic (b) antipyretic
(c) both (a) and (b) (d) none of these.

28. Chargaff's rule states that in an organism
(a) amount of adenine (A) is equal to that of thymine (T) and amount of guanine (G) is equal to that of cytosine (C)
(b) amount of adenine (A) is equal to that of guanine (G) and amount of thymine (T) is equal to that of cytosine (C)
(c) amount of adenine (A) is equal to that of cytosine (C) and amount of thymine (T) is equal to that of guanine (G)
(d) amounts of all bases are equal.

29. Polymer used in bullet proof glass is
(a) PMMA (b) Lexan
(c) Nomex (d) Kevlar.

30. In a polymer sample, 30% of molecules have a molecular mass of 20,000 u, 30% have 30,000 u and rest 40,000 u. What is the average molecular mass of the polymer?
(a) 29,000 u (b) 30,000 u
(c) 31,000 u (d) 32,000 u

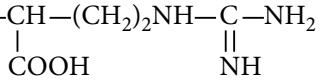
SOLUTIONS

1. **(a)**

2. **(d) :** Natural rubber is *cis*-polyisoprene while gutta-percha is *trans*-polyisoprene.

3. **(a) :** Heroin is not a tranquillizer, it is a narcotic analgesic.

4. **(b) :**



Arginine

α-Amino acids like arginine which contain two $—NH_2$ groups and one —COOH group are called basic amino acids.

5. **(c)** **6.** **(b)**

7. **(a) :** The disaccharide is sucrose, with α-glycosidic linkage between C_1 of glucose present in the pyranose form (ring i) and C_2 of fructose present in the furanose form (ring ii).

8. **(b)**

9. **(a) :** Cationic detergents are quaternary ammonium salts containing one or more long chain alkyl groups and possessing germicidal properties.

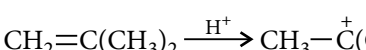
10. **(c)**

11. **(a) :** Acrilan is a polymer of acrylonitrile.

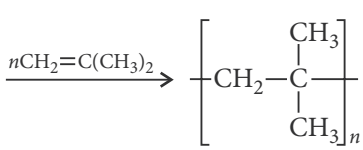
12. **(d) :** Saccharin is 550 times sweeter than sugar, aspartame is 100 times sweeter than sugar. Sucralose is 600 times sweeter than sugar.

13. **(a)**

14. **(b) :** Since 3° carbocations are most stable, the best way to obtain polyisobutylene is through cationic polymerisation in the presence of Lewis acid or protonic acid.



2-Methylpropene (Isobutylene)



Polyisobutylene

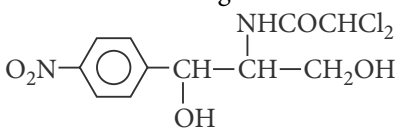
15. (b) : Liquid dishwashing detergents are of non-ionic type.

16. (c)

17. (c) : Neoprene is an elastomer, thus has weakest intermolecular forces. Nylon-6 is a fibre, thus has strong intermolecular forces like H-bonding. PVC is a thermoplastic polymer, thus the intermolecular forces present in PVC are in between those of elastomers and fibres. Thus, the order of intermolecular forces of these polymers is

Neoprene < PVC < Nylon-6

18. (d) : Among the given antibiotics, only chloramphenicol contains a nitro group attached to aromatic ring.



Chloramphenicol

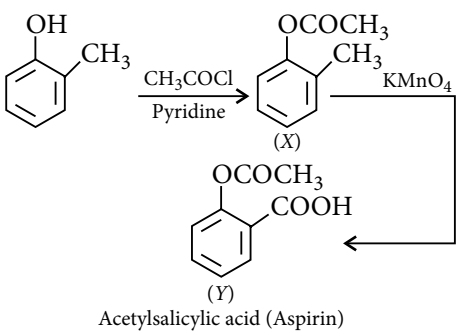
19. (a) : Since GC base pair has three H-bonds so it is more stable than AT base pair having two H-bonds. As DNA II has higher melting point than DNA I thus, it has more GC content than sample I.

20. (b) : Electron releasing groups such as $-CH_3$, $-OCH_3$ activate the monomer towards cationic polymerisation as these groups provide stability to the carbocation formed. Thus, the correct order is

$CH_2=CH-C_6H_4(OCH_3)$ > $CH_2=CH-C_6H_4(CH_3)$ > $CH_2=CH-C_6H_4(NO_2)$

(III) (II) (I)

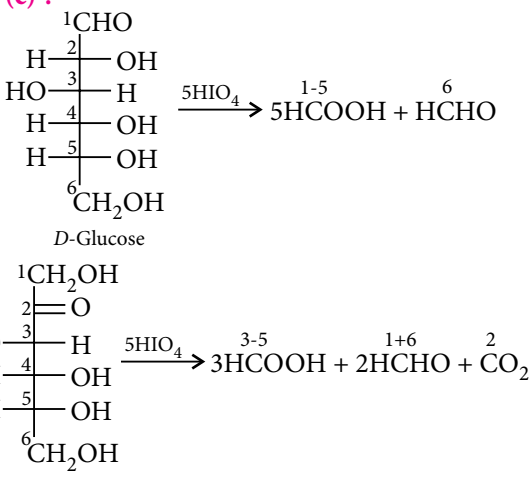
21. (d) :



Acetylsalicylic acid (Aspirin)

Aspirin acts as a gastric irritant.

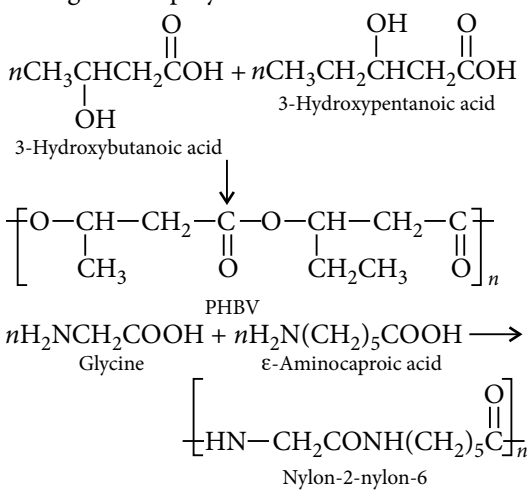
22. (c) :



D-Glucose

D-Fructose

23. (a) : PHBV and nylon-2-nylon-6 are biodegradable polymers.



3-Hydroxybutanoic acid

3-Hydroxypentanoic acid

PHBV

Glycine

ε-Aminocaproic acid

Nylon-2-nylon-6

24. (d) : Bithional is an antiseptic.

25. (c) **26. (b)** **27. (a)**

28. (a) : According to Chargaff's rule, the base composition in DNA varied from one organism to another but in all cases, the amount (in moles) of adenine was equal to that of thymine (A = T) and that of cytosine was equal to that of guanine (C = G).

29. (b)

30. (c) : Average molecular mass,

$$\bar{M}_n = \frac{30\times 20,000 + 30\times 30,000 + 40\times 40,000}{30+30+40}$$

$$= 31,000 \text{ u}$$

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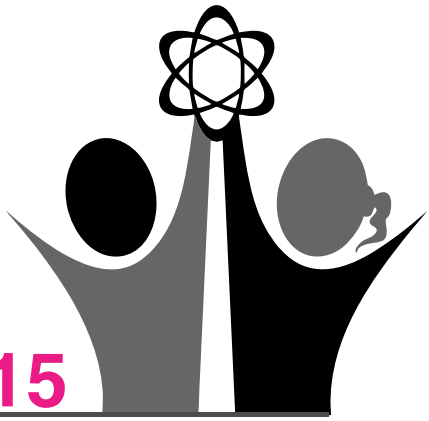
CHAPTERWISE PRACTICE PAPER 2015



Series-9 Polymers, Chemistry in Everyday Life

Time : 3 hrs. **Marks** : 70

GENERAL INSTRUCTIONS

(i) All questions are compulsory.
(ii) Question numbers 1 to 5 are very short-answer questions and carry 1 mark each.
(iii) Question numbers 6 to 10 are short-answer questions and carry 2 marks each.
(iv) Question numbers 11 to 22 are also short-answer questions and carry 3 marks each.
(v) Question number 23 is value based question and carries 4 marks.
(vi) Question numbers 24 to 26 are long-answer questions and carry 5 marks each.
(vii) Use Log Tables, if necessary. Use of calculator is not allowed.

1. Name the polymer used for insulation of electrical wires.

2. What type of drug is chloramphenicol?

3. What is the difference between nylon-6 and nylon-6,6?

4. Name the antibiotic supposed to be toxic towards certain strains of cancer cells.

5. Which type of compounds are present in antifertility drugs?

6. Give reason for the following :
(i) While antacid and antiallergic drugs interfere with the function of histamines, they do not interfere with the function of each other.
(ii) Overdoses of aspirin and its use on empty stomach should be avoided.

7. Classify the following as addition and condensation polymers.
(i) Terylene **(ii)** Bakelite
(iii) Polyvinyl chloride **(iv)** Polythene
Also write their monomers.

8. **(i)** How do antiseptics differ from disinfectants? Give one example of each.
(ii) Name a compound which can be used as an antiseptic as well as disinfectant.

9. **(i)** How does vulcanization change the properties of natural rubber?
(ii) Why are the numbers 66 and 6 put in the names of nylon-6, 6 and nylon-6?

10. Write the names and the structures of monomers of following polymers :
(i) Natural rubber
(ii) PHBV

OR

Distinguish between the terms homopolymer and copolymer and give an example of each.

11. What are detergents? Give the scheme of classification of synthetic detergents. Why are they preferred over soaps?

12. **(i)** Explain the term, target molecules or drug targets as used in medicinal chemistry.

(ii) Name the macromolecules that are chosen as drug targets.

(iii) Differentiate between agonists and antagonists.

13. How are polymers classified into different categories on the basis of intermolecular forces? Give one example of a polymer of each of these categories.

14. **(i)** What is the medicinal use of narcotic drugs?

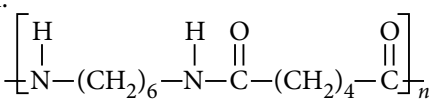
(ii) Why hair washed with hard water look dull?

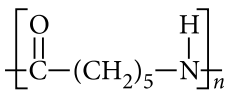
(iii) Why glycerol is added to soaps?

15. **(i)** What is the role of benzoyl peroxide in the polymerisation of ethene?

(ii) What are LDPE and HDPE? How are they prepared?

16. Write the names of monomers of the following polymers and mention one important use of each.

(i) 

(ii) 

(iii) $+CF_2-CF_2+_n$

17. **(i)** Give one important use of each of the following :

(a) Bithionol (b) Norethindrone

(c) Meprobamate (d) Aspartame

(ii) What class of drugs is ranitidine?

18. **(i)** Differentiate between addition and condensation polymers based on mode of polymerization. Give one example of each type.

(ii) Which polymer is obtained when free radical polymerisation of chloroprene occurs? Write the structure of polymer thus obtained.

19. **(i)** How does the presence of double bonds in rubber molecules influence their structure and reactivity?

(ii) Arrange the polymers nylon-6,6, buna-S and polythene in increasing order of their intermolecular forces and also give reason for the same.

OR

(i) Differentiate between novolac and bakelite on the basis of their structures.

(ii) Give two examples of biodegradable polymers.

(iii) How do you explain the functionality of monomer?

20. **(i)** Why cimetidine and ranitidine are better antacids than $NaHCO_3$ or $Mg(OH)_2$ or $Al(OH)_3$?

(ii) Why is the use of aspartame limited to cold foods and drinks?

21. **(i)** What are biodegradable and non-biodegradable detergents? What are the consequences of using latter class of detergents?

(ii) Label the hydrophilic and hydrophobic parts in the following compounds :

(a) $CH_3(CH_2)_{10}CH_2OSO_3^-Na^+$

(b) $CH_3(CH_2)_{15}\overset{+}{N}(CH_3)_3Br^-$

22. **(i)** Differentiate between narrow and broad spectrum antibiotics.

(ii) Give one example each of bactericidal and bacteriostatic antibiotics.

(iii) What are limited spectrum antibiotics?

23. Kavita noticed that she has put on a lot of weight. She immediately switched over to artificial sweeteners to reduce her sugar intake. Her friend Amrita, a class XII student suggested that instead of artificial sweeteners, she should control her weight by taking less sugar in diet, morning walk and daily exercise.

(i) What values are displayed by Amrita?

(ii) What are the consequences of using artificial sweeteners?

(iii) Name an artificial sweetener which is stable at cooking temperature.

(iv) Why artificial sweeteners are recommended for diabetic patients?

24. **(i)** Give free radical mechanism for the polymerisation of ethene.

(ii) Give one important use each of LDP and HDP with their properties.

OR

(i) Differentiate thermoplastic and thermosetting polymers with two examples of each.

(ii) Mention two important uses of each of the following :

(a) Bakelite (b) Glyptal

(iii) Give chemical equation for the preparation of terylene.

25. **(i)** What are receptors? Where are they located in the cell?

(ii) Explain how does a chemical messenger give message to the cell without entering the cell.

(iii) Explain the following terms with one example of each:

(a) Food preservatives (b) Enzymes

OR

(i) What are analgesic medicines? How are they classified and when are they commonly recommended for use?

(ii) Name one medicinal compound each for the treatment of :

(a) Hypertension (b) Acute pain

(iii) Write the structure of aspirin.

26. **(i)** How is bakelite made? Why is bakelite a thermosetting polymer?

(ii) Write the names of monomers of the following polymers and mention one important use of each.

(a) PVC (b) PMMA

(iii) Name the monomers of nylon-2-nylon-6.

OR

(i) Write the equations for the synthesis of

(a) Neoprene (b) Glyptal.

Which one of the two is a condensation polymer?

(ii) Write the equation for the preparation of

(a) An addition polymer

(b) A condensation polymer

(c) A copolymer.

SOLUTIONS

1. Buna-S

2. It is a broad spectrum antibiotic.

3. Nylon-6,6 is a copolymer of adipic acid and hexamethylenediamine whereas nylon-6 is a homopolymer of caprolactam.

4. Dysidazirine

5. Antifertility drugs contain a mixture of synthetic estrogen and progesterone derivatives.

6. **(i)** Antacid and antiallergic drugs work on different receptors, hence do not interfere with the function of each other.

(ii) Aspirin gets hydrolysed to form salicylic acid in stomach which produces ulcers and sometimes causes bleeding from the stomach wall.

7.

S. No.	Polymer	Type	Monomers
(i)	Terylene	Condensation	Terephthalic acid, ethylene glycol
(ii)	Bakelite	Condensation	Phenol, formaldehyde
(iii)	Polyvinyl chloride	Addition	Vinyl chloride
(iv)	Polythene	Addition	Ethene

8. **(i)** Antiseptics are applied to the living tissues such as wounds, cuts, ulcers and diseased skin surfaces *e.g.*, dettol whereas disinfectants are applied to inanimate objects such as floors, drains, instruments, etc *e.g.*, 0.2 – 0.4 ppm Cl_2 water.

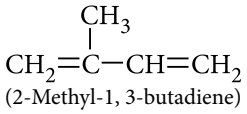
(ii) 0.2 % solution of phenol is used as an antiseptic whereas 1 % solution of phenol is used as a disinfectant.

9. **(i)** Rubber gets cross-linked through —S—S— bonds and becomes hard on vulcanization.

(ii) In nylon-6,6, two sixes stand for hexamethylenediamine (a monomer with 6 C–atoms) and adipic acid (another monomer with 6 C–atoms).

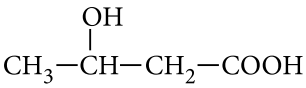
In nylon-6, six stands for the only monomer caprolactam (6C–atoms).

10. (i) Natural rubber : Isoprene



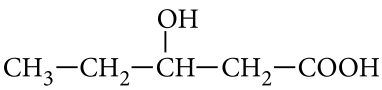
(2-Methyl-1, 3-butadiene)

(ii) PHBV :



3-Hydroxybutanoic acid

and



3-Hydroxypentanoic acid

OR

Homopolymer : A polymer made by polymerisation of a single monomer chemical species is known as homopolymer.

e.g. Polythene made by ethene molecules.

Copolymer : A polymer made by polymerisation of two or more different monomers is known as copolymer.

e.g., Buna-S made by 1, 3-butadiene and styrene.

11. A detergent is a surface active agent used for cleaning dirty surfaces. It contains a non polar hydrocarbon chain (hydrophobic part) and polar group (hydrophilic part) within the molecule.

On the basis of charge on polar part, synthetic detergents are classified as follows :

(i) Anionic detergents in which large part of the molecules are anions *e.g.*, sodium alkylbenzenesulphonates.

(ii) Cationic detergents in which large part of the molecules are cations. These are mostly acetates or chlorides or bromides of quaternary amines *e.g.*, cetyltrimethylammonium bromide.

(iii) Non-ionic detergents do not contain any ions. These are esters of high molecular mass alcohols obtained by reaction between polyethylene glycol and stearic acid.

Synthetic detergents are preferred over soaps as :

- they work even in hard water and acidic water whereas soaps become insoluble.
- they have powerful cleansing action than soaps.
- they are more soluble in water and hence produce lather more easily than soaps. They produce lather even in ice cold water.

12. (i) Drugs usually interact with biological macromolecules, called target molecules or drug targets.

(ii) The macromolecules chosen as drug targets are carbohydrates, proteins, lipids and nucleic acids.

(iii) Drugs that bind to the receptor site and inhibit its natural function are called antagonists whereas drugs that mimic the natural messenger by switching on the receptor, are called agonists.

13. On the basis of intermolecular forces, polymers are classified into :

(i) Elastomers : Polymer chains are held together by the weakest intermolecular forces and these type of polymers can be stretched. *e.g.*, Buna-S, Buna-N.

(ii) Fibres : They are thread forming with high tensile strength and high modulus and possess strong intermolecular forces *e.g.*, nylon-6,6, terylene.

(iii) Thermoplastic polymers : These are the linear or slightly branched long chain molecules and have the properties of softening on heating and hardening on cooling. Intermolecular forces of attraction are in between those of elastomers and fibres. *e.g.*, PVC and polythene.

(iv) Thermosetting polymers : There is extensive cross linking between different polymer chains forming three dimensional network of bonds, and on heating polymer becomes infusible *e.g.*, bakelite, urea-formaldehyde resin.

14. (i) Narcotic drugs are chiefly used for the relief of postoperative pain, cardiac pain and pains of terminal cancer and in child birth.

(ii) Calcium and magnesium ions present in hard water form insoluble calcium and magnesium soaps respectively when soaps are dissolved in hard water. The sticky precipitate so formed makes the hair look dull.

(iii) Glycerol is added to soaps to prevent quick drying.

15. (i) Benzoyl peroxide produces free radical which acts as chain initiator in the polymerisation of ethene to polythene.

(ii) LDPE (Low density polythene) : It is a branched chain polymer.

Preparation : Polymerisation of ethene at high temperature (350 - 570 K) and pressure (1000 - 2000 atm) in the presence of a peroxide initiator.

HDPE (High density polythene) : It is a straight chain polymer.

Preparation : It is prepared by heating ethylene in a hydrocarbon solvent in the presence of Ziegler-Natta catalyst at a temperature of 333 to 343 K and under a pressure of 6-7 atm.

16. (i) Monomer – adipic acid and hexamethylenediamine.

Use : It is used for making bristles for brushes.

(ii) Monomer – caprolactam.

Use : It is used for making tyre cords.

(iii) Monomer – tetrafluoroethene.

Use : It is used for making non-stick utensils.

17. (i) (a) Bithionol – Imparts antiseptic properties to soaps

(b) Norethindrone – Antifertility drug

(c) Meprobamate – Mild tranquillizer suitable for relieving tension

(d) Aspartame – Artificial sweetener

(ii) Ranitidine is an antacid.

18. (i) **Addition polymers :** The polymers formed by the addition reaction of a large number of unsaturated monomers are called addition polymers.

For example : Polythene, polystyrene.

Condensation polymers : The polymers formed by the condensation of two or more bifunctional monomers are called condensation polymers.

For example : Nylon 6,6, bakelite.

(ii) Neoprene is obtained by free radical polymerisation of chloroprene.

$$n\underset{\text{Chloroprene}}{CH_2=\underset{Cl}{\overset{|}{C}}-CH=CH_2} \xrightarrow[\text{or } O_2]{\text{Peroxide}} \underset{\text{Neoprene}}{+CH_2-\underset{Cl}{\overset{|}{C}}=CH-CH_2+_n}$$

19. (i) Natural rubber is *cis*-polyisoprene because of which the polymer chains cannot come close to each other and get coiled as a result of steric hindrance. This causes them to have weak van der Waals interactions between the molecules, and hence they possess elastic property, vulnerability to oxidation, solubility in organic solvents, etc.

(ii) The increasing order of intermolecular forces is buna-S < polythene < nylon-6, 6.

Elastomers or rubbers have the weakest intermolecular forces of attraction followed by plastics while fibres have the strongest forces of attraction. Thus, the increasing intermolecular forces of attraction follows the order : Elastomer < Plastic < Fibre.

OR

(i) Novolac is a linear polymer and bakelite is a cross-linked polymer of phenol and formaldehyde.

(ii) Poly-β-hydroxybutyrate-co-β-hydroxyvalerate (PHBV) and nylon-2-nylon-6.

(iii) Functionality of monomer is defined as number of bonding sites in the monomer.

20. (i) Over production of acid in stomach causes irritation and pain, and also ulcers are developed in the stomach in some cases. $NaHCO_3$ makes the stomach alkaline and trigger the production of more acid. $Mg(OH)_2$ and $Al(OH)_3$ being insoluble, however are better than $NaHCO_3$ and do not increase the pH. However, these

treatments control only symptoms, and not the cause. Cimetidine and ranitidine prevent the interaction of histamine with the receptors present in the stomach wall. This results in the release of lesser amount of acid.

(ii) Use of aspartame is limited to cold foods and drinks because at cooking temperature, it is unstable.

21. (i) Biodegradable detergents are those which are decomposed by micro-organisms like bacteria into harmless products. Detergents having linear alkyl chains are biodegradable. *e.g.*, Sodium lauryl sulphate, sodium-4-(1-dodecyl)benzene sulphonate.

Non-biodegradable detergents are those which are not decomposed by micro-organisms. Detergents with branched chains are non-biodegradable.

e.g., Sodium-4-(1,3,5,7-tetramethyloctyl) benzene sulphonate, etc.

Slow degradation of non-biodegradable detergents leads to their accumulation. Effluents containing such detergents reach the rivers, ponds, etc. These persist in water even after sewage treatment and cause foaming in rivers, ponds and streams and their water gets polluted. Biodegradable detergents do not cause water pollution.

(ii) (a) $\underbrace{CH_3(CH_2)_{10}CH_2}_{\text{Hydrophobic}}\underbrace{OSO_3^-Na^+}_{\text{Hydrophilic}}$

(b) $\underbrace{CH_3(CH_2)_{15}}_{\text{Hydrophobic}}\underbrace{\overset{+}{N}(CH_3)_3Br^-}_{\text{Hydrophilic}}$

22. (i) Antibiotics which kill or inhibit a wide range of Gram-positive and Gram-negative bacteria are called broad spectrum antibiotics while those only effective against either of Gram-positive or Gram-negative bacteria are called narrow spectrum antibiotics.

(ii) Bactericidal – Penicillin
Bacteriostatic – Erythromycin

(iii) Antibiotics which are effective against a single organism or disease are called limited spectrum antibiotics.

23. (i) Amrita expressed concern about the health of her friend and she believes that disciplined life is the key factor for good health.

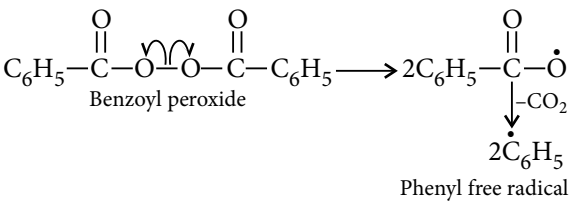
(ii) Artificial sweeteners are not excreted easily from the body and hence, produce harmful effects.

(iii) Sucralose

(iv) Diabetic patients need to control their sugar intake and artificial sweeteners provide sweet taste without supplying calories.

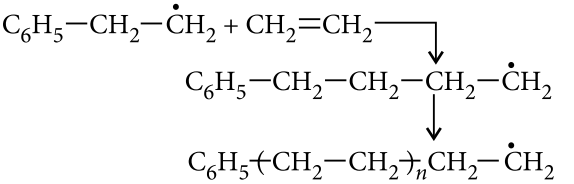
24. (i) The sequence of steps involved in free radical polymerisation of ethene may be depicted as follows :

Chain initiation step :



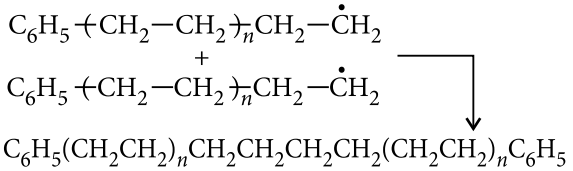
$$\dot{C}_6H_5 + CH_2{=}CH_2 \longrightarrow C_6H_5{-}CH_2{-}\dot{C}H_2$$

Chain propagating step :



Chain terminating step :

For termination of the long chain, these free radicals can combine in different ways to form polythene. One mode of termination of chain is shown by combination of free radicals :



(ii) **LDP :** It is chemically inert, slightly flexible and is a poor conductor of electricity.
Used in manufacture of squeeze bottles and flexible pipes.
HDP : It is also chemically inert but has greater toughness, hardness and tensile strength than LDP.
Used for manufacturing buckets, dustbins, etc.

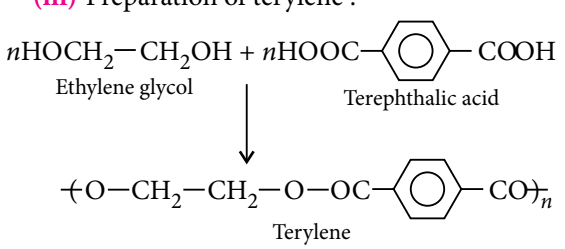
OR

(i)

S. No.	Thermoplastic polymers	Thermosetting polymers
1.	These soften and melt on heating and hence can be remoulded, recast and reshaped.	These do not soften on heating and hence cannot be remoulded or reshaped.
2.	These usually have linear structures and are formed by addition polymerization.	These have three dimensional cross-linked structures and are formed by condensation polymerization.
3.	Examples : Polyethylene, Polystyrene.	Examples : Bakelite, Urea-formaldehyde resin.

(ii) (a) Bakelite is used for making combs and electrical switches.
(b) Glyptal is used for manufacture of paints and lacquers.

(iii) Preparation of terylene :



25. (i) Receptors are proteins that are crucial to body's communication process. Majority of these are embedded in the cell membranes. Receptor proteins are embedded in the cell membrane in such a way that their small part possessing active site projects out of the surface of the membrane and opens on the outside region of the cell membrane.

(ii) Chemical messengers are received at the binding sites of receptor proteins. To accommodate a messenger, shape of the receptor site changes. This brings about the transfer of message into the cell. Thus, chemical messenger gives message to the cell without entering the cell.

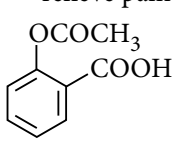
(iii) (a) Preservatives are the substances used to prevent spoilage of food due to microbial growth during storage *e.g.*, sodium benzoate.
(b) The proteins which perform the role of biological catalysts in the body are called enzymes *e.g.*, trypsin.

OR

(i) The chemical substances which are used to relieve pain are called analgesic medicines.
There are two types of analgesic medicines:
(a) Non-narcotic drugs : These are non-addictive drugs and are effective in relieving skeletal pain, preventing heart attack and viral inflammation.
(b) Narcotic drugs : These are the drugs which when administered in small doses relieve pain and produce sleep. However, in large doses, they produce stupor, coma and may ultimately cause death. These are recommended for the relief in postoperative pain, cardiac pain, pains of terminal cancer, and child birth. These are morphine derivatives and habit forming.

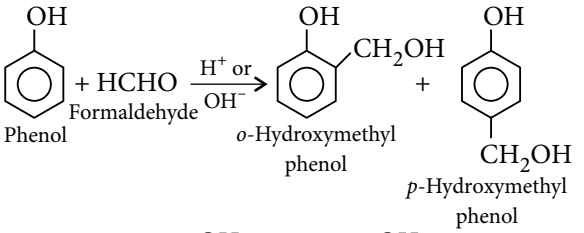
(ii) (a) Equanil is used to reduce hypertension.
(b) Morphine and many of its homologues, when administered in medicinal doses, relieve pain and produce sleep.

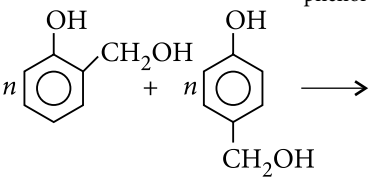
(iii)

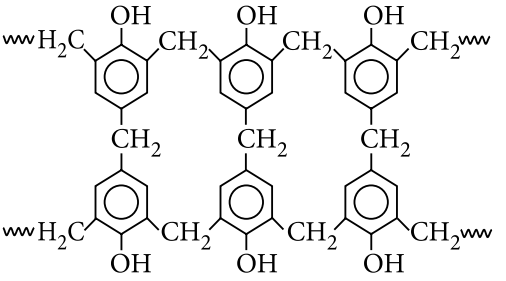


Aspirin

26. (i) Bakelite is prepared by condensation polymerisation of phenol and formaldehyde. Phenol and formaldehyde react in presence of acid or alkali to form *o*-hydroxymethylphenol and/or *p*-hydroxymethylphenol. These two hydroxyphenol derivatives further react with phenol to form compounds having rings joined to each other through $-CH_2$ groups. The initial product could be a linear product—Novolac. Novolac on heating with formaldehyde undergoes cross-linking to form an infusible solid mass called bakelite.







Bakelite is a thermosetting polymer because it cannot be remoulded on heating due to high degree of cross-linking between different polymer chains.

(ii) (a) For PVC, the monomer unit is vinyl chloride,

$$CH_2=CH-Cl$$

PVC is used in the manufacture of raincoats, handbags, vinyl flooring, etc.

(b) The monomer unit for PMMA is methyl methacrylate,

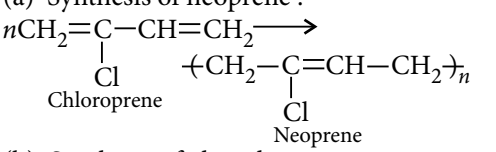
$$CH_2=\underset{\displaystyle CH_3}{\overset{|}{C}}-COOCH_3$$

PMMA is used as a substitute of glass and making decorative materials.

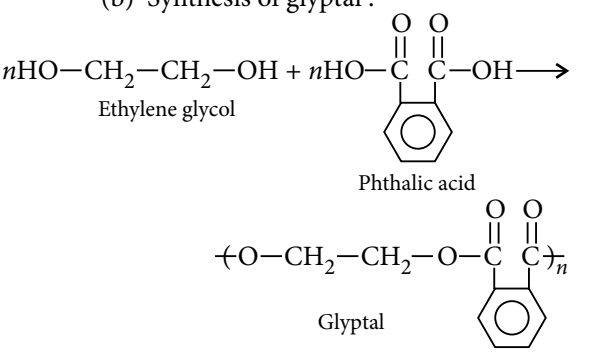
(iii) Monomers of nylon-2-nylon-6 are glycine (H_2N-CH_2-COOH) and ε-aminocaproic acid ($H_2N-(CH_2)_5-COOH$).

OR

(i) (a) Synthesis of neoprene :

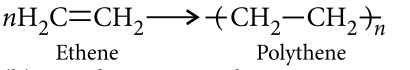


(b) Synthesis of glyptal :

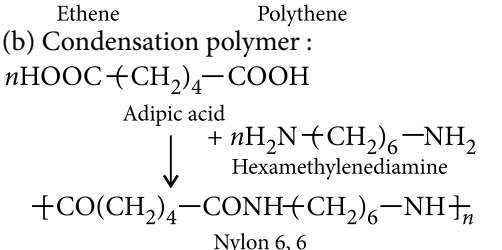


Out of these two, glyptal is a condensation polymer.

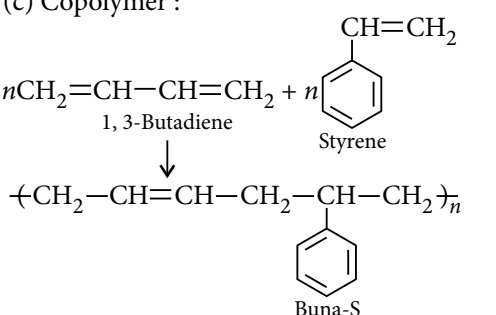
(ii) (a) Addition polymer :

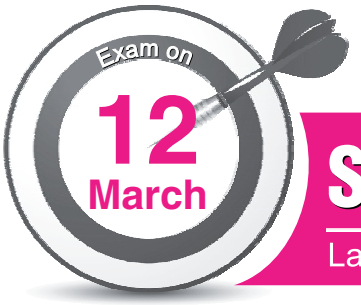


(b) Condensation polymer :



(c) Copolymer :





Score High in CBSE Board

Last 3 Years Chapterwise Questions | **Physical Chemistry**

THE SOLID STATE

1. (a) What type of semiconductor is obtained when silicon is doped with boron?

(b) What type of magnetism is shown in the following alignment of magnetic moments?

↑ ↑ ↑ ↑ ↑ ↑

(c) What type of point defect is produced when AgCl is doped with $CdCl_2$?

(Delhi 2013, 3 marks)

2. Tungsten crystallises in body centred cubic unit cell. If the edge of the unit cell is 316.5 pm, what is the radius of tungsten atom?

(Delhi 2012, 3 marks)

3. Iron has a body centred cubic unit cell with a cell dimension of 286.65 pm. The density of iron is 7.874 g cm^{-3}. Use this information to calculate Avogadro's number. (At. mass of Fe = 55.845 u)

(Delhi, AI 2012, 3 marks)

SOLUTIONS

4. (a) Define the following terms:

(i) Molarity

(ii) Molal elevation constant (K_b)

(b) A solution containing 15 g urea (molar mass = 60 g mol^{-1}) per litre of solution in water has the same osmotic pressure (isotonic) as a solution of glucose (molar mass = 180 g mol^{-1}) in water. Calculate the mass of glucose present in one litre of its solution.

(AI 2014, 5 marks)

5. (a) What type of deviation is shown by a mixture of ethanol and acetone? Give reason.

(b) A solution of glucose (molar mass = 180 g mol^{-1}) in water is labelled as 10% (by mass). What would be the molality and molarity of the solution?
(Density of solution = 1.2 g mL^{-1})

(AI 2014, 5 marks)

6. Determine the osmotic pressure of a solution prepared by dissolving 2.5×10^{-2} g of K_2SO_4 in 2 L of water at 25°C, assuming that it is completely dissociated.
(R = 0.0821 L atm K^{-1} mol^{-1}, Molar mass of K_2SO_4 = 174 g mol^{-1})

(Delhi 2013, 3 marks)

7. 15.0 g of an unknown molecular material was dissolved in 450 g of water. The resulting solution was found to freeze at – 0.34°C. What is the molar mass of this material?
(K_f for water = 1.86 K kg mol^{-1})

(Delhi 2012, 3 marks)

8. Calculate the amount of KCl which must be added to 1 kg of water so that the freezing point is depressed by 2 K.
(K_f for water = 1.86 K kg mol^{-1})

(Delhi 2012, 3 marks)

9. (a) Explain the following:

(i) Henry's law about dissolution of a gas in a liquid.

(ii) Boiling point elevation constant for a solvent.

(b) A solution of glycerol ($C_3H_8O_3$) in water was prepared by dissolving some glycerol in 500 g of water. This solution has a boiling point of 100.42°C. What mass of glycerol was dissolved to make this solution?
(K_b for water = 0.512 K kg mol^{-1})

(AI 2012, 5 marks)

ELECTROCHEMISTRY

10. (a) Define the following terms:
(i) Limiting molar conductivity
(ii) Fuel cell

(b) Resistance of a conductivity cell filled with 0.1 mol L^{-1} KCl solution is 100 Ω. If the resistance of the same cell when filled with 0.02 mol L^{-1} KCl solution is 520 Ω, calculate the conductivity and molar conductivity of 0.02 mol L^{-1} KCl solution. The conductivity of 0.1 mol L^{-1} KCl solution is 1.29×10^{-2} Ω^{-1} cm^{-1}.

(Delhi 2014, 5 marks)

11. (a) State Faraday's first law of electrolysis. How much charge in terms of Faraday is required for the reduction of 1 mole of Cu^{2+} to Cu?

(b) Calculate the emf of following cell at 298 K:
$Mg_{(s)} \mid Mg^{2+}(0.1\ M) \parallel Cu^{2+}(0.01) \mid Cu_{(s)}$
(Given : $E^\circ_{cell} = +2.71$ V, 1 F = 96500 C mol^{-1})

(Delhi 2014, 5 marks)

12. (a) Calculate $\Delta_r G^\circ$ for the reaction:

$$Mg_{(s)} + Cu^{2+}_{(aq)} \longrightarrow Mg^{2+}_{(aq)} + Cu_{(s)}$$

(Given : $E^\circ_{cell} = +2.71$ V, 1 F = 96500 C mol^{-1})

(b) Name the type of cell which was used in Apollo space programme for providing electrical power. **(AI 2014, 3 marks)**

13. Calculate the emf of the following cell at 298 K
$Fe_{(s)} \mid Fe^{2+}(0.001\ M) \mid\mid H^+(1\ M) \mid H_{2(g)}(1\ bar), Pt_{(s)}$
(Given : $E^\circ_{cell} = +0.44$ V)

(Delhi 2013, 3 marks)

14. Calculate the emf of the following cell at 25°C:
$Ag_{(s)} \mid Ag^+(10^{-3}\ M) \mid\mid Cu^{2+}(10^{-1}\ M) \mid Cu_{(s)}$
(Given : $E^\circ_{cell} = +0.46$ V and $\log 10^n = n$)

(AI 2013, 3 marks)

15. (a) What type of a battery is the lead storage battery? Write the anode and the cathode reactions and the overall reaction occurring in a lead storage battery when current is drawn from it.

(b) In the button cell, widely used in watches, the following reaction takes place.

$$Zn_{(s)} + Ag_2O_{(s)} + H_2O_{(l)} \longrightarrow Zn^{2+}_{(aq)} + 2Ag_{(s)} + 2OH^-_{(aq)}$$

Determine E° and ΔG° for the reaction.
(Given : $E^\circ_{Ag^+/Ag} = +0.80$ V, $E^\circ_{Zn^{2+}/Zn} = -0.76$ V)

(Delhi, AI 2012, 5 marks)

16. (a) Define molar conductivity of a solution and explain how molar conductivity changes with change in concentration of solution for a weak and a strong electrolyte.

(b) The resistance of a conductivity cell containing 0.001 M KCl solution at 298 K is 1500 Ω. What is the cell constant if the conductivity of 0.001 M KCl solution at 298 K is 0.146×10^{-3} S cm^{-1}?

(Delhi, AI 2012, 5 marks)

17. The electrical resistance of a column of 0.05 M NaOH solution of diameter 1 cm and length 50 cm is 5.5×10^3 ohm. Calculate its resistivity, conductivity and molar conductivity.

(AI 2012, 3 marks]

18. A voltaic cell is set up at 25°C with the following half cells:
$Al/Al^{3+}(0.001\ M)$ and $Ni/Ni^{2+}(0.50\ M)$
Write an equation for the reaction that occurs when the cell generates an electric current and determine the cell potential.
$E^\circ_{Ni^{2+}/Ni} = -0.25$ V and $E^\circ_{Al^{3+}/Al} = -1.66$ V
($\log 8 \times 10^{-6} = -5.09$)

(AI 2012, 3 marks)

CHEMICAL KINETICS

19. The following data were obtained during the first order thermal decomposition of SO_2Cl_2 at a constant volume:

$$SO_2Cl_{2(g)} \longrightarrow SO_{2(g)} + Cl_{2(g)}$$

Experiment	Time/s	Total pressure/atm
1	0	0.4
2	100	0.7

Calculate the rate constant.
(Given : $\log 4 = 0.6021$, $\log 2 = 0.3010$)

(Delhi, AI 2014, 3 marks)

20. (a) A reaction is second order in *A* and first order in *B*.
(i) Write the differential rate equation.
(ii) How is the rate affected on increasing the concentration of *A* three times?
(iii) How is the rate affected when the concentrations of both *A* and *B* are doubled?

(b) A first order reaction takes 40 minutes for 30% decomposition. Calculate $t_{1/2}$ for this reaction.
(Given : log 1.428 = 0.1548)

(Delhi 2013, 5 marks)

21. (a) For a first order reaction, show that time required for 99% completion is twice the time required for the completion of 90% of reaction.

(b) Rate constant 'k' of a reaction varies with temperature 'T' according to the equation:

$$\log k = \log A - \frac{E_a}{2.303\,R}\left(\frac{1}{T}\right)$$

where E_a is the activation energy. When a graph is plotted for log k *vs* $\frac{1}{T}$, a straight line with a slope of – 4250 K is obtained. Calculate E_a for the reaction.
(R = 8.314 J K^{-1} mol^{-1})

(Delhi 2013, 5 marks)

22. The rate of a reaction becomes four times when the temperature changes from 293 K to 313 K. Calculate the energy of activation (E_a) of the reaction assuming that it does not change with temperature.
(R = 8.314 J K^{-1} mol^{-1}, log 4 = 0.6021)

(AI 2013, 3 marks)

23. For the reaction:

$$2NO_{(g)} + Cl_{2(g)} \longrightarrow 2NOCl_{(g)}$$

the following data were collected. All the measurements were taken at 263 K.

Exp. No.	Initial [NO] (M)	Initial [Cl_2] (M)	Initial rate of disapp. of Cl_2 (M/min)
1	0.15	0.15	0.60
2	0.15	0.30	1.20
3	0.30	0.15	2.40
4	0.25	0.25	?

(a) Write the expression for rate law.

(b) Calculate the value of rate constant and specify its units.

(c) What is the initial rate of disappearance of Cl_2 in exp. 4?

(Delhi 2012, 3 marks)

SURFACE CHEMISTRY

24. (a) In reference to Freundlich adsorption isotherm write the expression for adsorption of gases on solids in the form of an equation.

(b) Write an important characteristic of lyophilic sols.

(c) Based on type of particles of dispersed phase, give one example each of associated colloid and multimolecular colloid.

(Delhi 2014, 3 marks)

25. What are emulsions? What are their different types? Give one example of each type.

(AI 2014, 3 marks)

26. What are the characteristics of the following colloids? Give one example of each.

(i) Multimolecular colloids

(ii) Lyophobic sols

(iii) Emulsions

(AI 2013, 3 marks)

27. Define the following terms giving an example of each:

(i) Associated colloids

(ii) Lyophilic sols

(iii) Adsorption

(AI 2013, 3 marks)

28. Explain the following terms giving a suitable example for each:

(i) Aerosol

(ii) Emulsion

(iii) Micelle

(AI 2012, 5 marks)

29. Write three distinct features of chemisorptions which are not found in physisorptions.

(AI 2012, 3 marks)

SOLUTIONS

1. (a) *p*-type semiconductor
(b) Ferromagnetism
(c) Impurity defect

2. For *bcc* structure, $r = \frac{\sqrt{3}}{4}a$

a = 316.5 pm

$r = \frac{\sqrt{3}}{4} \times 316.5 = 137.04$ pm

3. a = 286.65 pm = 286.65 × 10^{-10} cm
ρ = 7.874 g cm^{-3}, Z = 2 (for *bcc*)
M = 55.845 u

$$\rho = \frac{ZM}{a^3 N_A}$$

$$N_A = \frac{ZM}{a^3\rho} = \frac{2 \times 55.845}{(286.65 \times 10^{-10})^3 \times 7.874}$$

$N_A = 6.022 \times 10^{23}$

4. (a) (i) Molarity : Number of moles of solute dissolved in one litre solution is called molarity. It is denoted by M.

$$M = \frac{\text{Number of moles of solute}}{\text{Volume of solution in litre}} = \frac{n_2}{V \text{ in L}}$$

or, $$M = \frac{\text{Mass of solute in g} \times 1000}{\text{Gram molecular mass of solute} \times \text{Volume of solution in mL}}$$

$$= \frac{W_2 \times 1000}{M_2 \times V(\text{in mL})}$$

(ii) Molal elevation constant : The elevation in boiling point when one mole of solute is added to one kg of solvent. It is denoted by K_b.

(b) Given : Mass of urea = 15 g
Molar mass of urea = 60 g mol^{-1}
Molar mass of glucose = 180 g mol^{-1}
Mass of glucose = ?
For isotonic solution, osmotic pressure

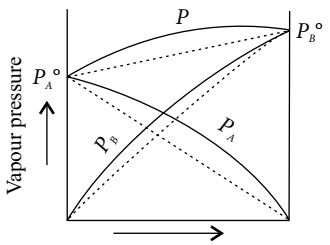
$\pi_1 = \pi_2$

$n_1 = n_2$ (when volume is same)

or $$\frac{w_1}{M_1} = \frac{w_2}{M_2} \Rightarrow \frac{15}{60} = \frac{w_2}{180}$$

$$\Rightarrow w_2 = \frac{15 \times 180}{60} = 45 \text{ g}$$

5. (a) Mixture shows non-ideal solution with positive deviation when intermolecular forces between $A - B$ are weaker than that between $A - A$ and $B - B$.
In this case intermolecular force decreases, volume increases, vapour pressure increases, enthalpy increases.
ΔV_{mixing} = + ve, ΔH_{mixing} = + ve, ΔP = + ve.
So, it shows non-ideal solution with positive deviation.
$P_A > x_A P_A°$, $P_B > x_B P_B°$ and $P > x_A P_A° + x_B P_B°$



(b) Given : Mass of solute w_2 = 10 g
Mass of solvent w_1 = 90 g
Molar mass of solute M_2 = 180 g mol^{-1}
Density of solution = 1.2 g mL^{-1}

$$\text{Molality, } m = \frac{w_2 \times 1000}{M_2 \times w_1} = \frac{10 \times 1000}{180 \times 90}$$

$$= 0.62 \text{ mol kg}^{-1}$$

$$\text{Volume of solution} = \frac{\text{Mass}}{\text{Density}} = \frac{100 \text{ g}}{1.2 \text{ g mL}^{-1}}$$

$$\text{Molarity, } M = \frac{w_2 \times 1000}{M_2 \times V}$$

$$= \frac{10 \times 1000}{180 \times \frac{100}{1.2}} = \frac{10 \times 1000 \times 1.2}{180 \times 100}$$

$$= 0.66 \text{ mol L}^{-1}$$

6. K_2SO_4 dissolved = 2.5 × 10^{-2} g
Volume of solution = 2 L, T = 25°C = 298 K
Molar mass of K_2SO_4 = 174 g mol^{-1}
K_2SO_4 dissociates completely as

$$K_2SO_4 \rightarrow 2K^+ + SO_4^{2-}$$

$\therefore$ Ions produced = 3, $\therefore$ $i = 3$

$$\therefore \quad \pi = iCRT = i\frac{n}{V}RT = i \times \frac{w}{M} \times \frac{1}{V} \times RT$$

$$= 3 \times \frac{2.5\times10^{-2}}{174} \times \frac{1}{2} \times 0.0821 \times 298$$

$$= 5.27 \times 10^{-3} \text{ atm}$$

7. $\Delta T_f = K_f \times \frac{w_B \times 1000}{M_B \times w_A}$

$w_B = 15.0$ g, $w_A = 450$ g

$\Delta T_f = 0 - (-0.34) = +0.34°C$

$K_f = 1.86$ K kg mol^{-1}, $M_B = ?$

$$M_B = K_f \times \frac{w_B \times 1000}{\Delta T_f \times w_A} = \frac{1.86\times15.0\times1000}{0.34\times450}$$

$\therefore \quad M_B = 182.4$ g/mol

8. $\Delta T_f = 2$ K, $K_f = 1.86$ K kg mol^{-1}

$w_{\text{solvent}} = 1$ kg, $\Delta T_f = i\, K_b\, m$

$$m = \frac{\text{Moles of KCl}}{\text{Weight of solvent (g)}} \times 1000$$

$$\Delta T_f = \frac{\text{Moles of KCl}}{\text{Weight of solvent (g)}} \times 1000 \times i \times K_b$$

[$\because$ $i = 2$ for KCl]

$$2 = \frac{\text{Moles of KCl}}{1000} \times 1000 \times 2 \times 1.86$$

$$\text{Moles of KCl} = \frac{1}{1.86}$$

$$\frac{\text{Weight}}{\text{Mol. wt.}} = \frac{\text{Weight}}{74.5} = \frac{1}{1.86}$$

$$\text{Weight} = \frac{74.5}{1.86} = 40 \text{ g}$$

9. (a) (i) Henry's law states that the solubility of a gas in a liquid is directly proportional to the pressure of the gas.

(ii) Ebullioscopic constant is the boiling point elevation when one mole of solute is dissolved in 1000 g of solvent. It is denoted by K_b.

(b) Given, $w_1 = 500$ g, $M_2 = 92$ g mol^{-1}

$w_2 = ?$

$\because$ $\Delta T_b = (100.42 - 100)°C = 0.42°C = 0.42$ K

$\because$ $\Delta T_b = K_b.m$

$$\Delta T_b = K_b \times \frac{w_2 \times 1000}{M_2 \times w_1}$$

$$\Rightarrow \quad 0.42 = \frac{0.512 \times w_2 \times 1000}{92 \times 500}$$

$$\Rightarrow \quad w_2 = \frac{0.42 \times 92 \times 500}{0.512 \times 1000} = 37.7 \text{ g}$$

10. (a) (i) Limiting molar conductivity : In a solution of an electrolyte, when the concentration approaches zero, the molar conductivity attains a definite value known as limiting molar conductivity. It is denoted by Λ°_m.

(ii) Fuel cell : Those devices which give us direct electrical energy by the combustion of fuels like hydrogen, methane, methanol etc are called fuel cells.

(b) Resistance of 0.1 M KCl solution, $R = 100\ \Omega$

Conductivity, $\kappa = 1.29$ S m^{-1}

Cell constant, $G^* = \kappa \times R = 1.29 \times 100$

$= 129$ m^{-1}

Resistance of 0.02 M KCl solution, $R = 520\ \Omega$

$$\text{Conductivity, } \kappa = \frac{\text{Cell constant}}{R}$$

$$= \frac{129 \text{ m}^{-1}}{520\ \Omega} = 0.248 \text{ S m}^{-1}$$

Concentration, $C = 0.02$ mol L^{-1}

$= 1000 \times 0.02$ mol m^{-3}

$= 20$ mol m^{-3}

$$\text{Molar conductivity, } \Lambda_m = \frac{\kappa}{C} = \frac{0.248 \text{ S m}^{-1}}{20 \text{ mol m}^{-3}}$$

$= 0.0124$ S m^2 mol^{-1}

11. (a) Faraday's first law of electrolysis : The amount of chemical reaction which occurs at any electrode is proportional to the quantity of electricity passed through the electrolyte (solution or melt).

The electrode reaction is $Cu^{2+} + 2e^- \rightarrow Cu$

$\therefore$ Quantity of charge required for reduction of 1 mole of $Cu^{2+} = 2$ F $= 2 \times 96500$

$= 193000$ C

(b) The cell reaction can be represented as:

$Mg_{(s)} + Cu^{2+}_{(aq)} \rightarrow Mg^{2+}_{(aq)} + Cu_{(s)}$

Given: $E^\circ_{\text{cell}} = +2.71$ V, $T = 298$ K

According to the Nernst equation:

$$E_{\text{cell}} = E^\circ_{\text{cell}} - \frac{0.0591}{n} \log \frac{[Mg^{2+}_{(aq)}]}{[Cu^{2+}_{(aq)}]}$$

$$= 2.71 - \frac{0.0591}{2} \log \frac{0.1}{0.01} = 2.6805 \text{ V}$$

12. (a) Given : $E^\circ_{cell} = +2.71$ V

For the reaction,

$Mg_{(s)} + Cu^{2+}_{(aq)} \longrightarrow Mg^{2+}_{(aq)} + Cu_{(s)}$

$n = 2, \Delta_r G^\circ = ?$

$\Delta_r G^\circ = -nFE^\circ$

$\Delta_r G^\circ = -2 \times 96500\ C\,mol^{-1} \times 2.71\ V$

$= 523.03\ kJ\ mol^{-1}$

(b) H_2–O_2 fuel cell was used in Appollo space programme.

13. The electrode reactions in this cell are

At anode : $Fe_{(s)} \rightarrow Fe^{2+}(0.001\ M) + 2e^-$

At cathode : $2H^+(1\ M) + 2e^- \rightarrow H_2(1\ bar)$

Net reaction :

$Fe_{(s)} + 2H^+(1\ M) \rightarrow Fe^{2+}(0.001\ M) + H_2(1\ bar)$

The Nernst equation of this cell at 25°C

$$E_{cell} = E^\circ_{cell} - \frac{0.0591}{2}\log\frac{[Fe^{2+}][H_2]}{[Fe_{(s)}][H^+]^2}$$

$$E_{cell} = 0.44 - \frac{0.0591}{2}\log\frac{0.001\times 1}{(1)^2}$$

$$= 0.44 - 0.0296\log\left(\frac{1}{1000}\right)$$

$= 0.44 - 0.0296\log(10^{-3})$

$= 0.44 + (3 \times 0.0296) = 0.44 + 0.0888$

$E_{cell} = +0.53$ V

14. The cell may be represented as

$Cu_{(s)}|Cu^{2+}\ (0.1\ M)||Ag^+\ (0.001\ M)|Ag_{(s)}$

$$E = E^\circ_{cell} - \frac{0.0591}{2}\log\frac{[Cu^{2+}]}{[Ag^+]^2}$$

$$E = 0.46\ V - 0.0295\log\frac{10^{-1}}{(10^{-3})^2}$$

$= 0.46 - 0.0295 \times \log 10^5 = 0.46 - 0.0295 \times 5$

$= 0.46 - 0.1475 = 0.3125$ V

15. (a) Lead storage battery is a secondary battery. In these batteries the reactions can be reversed by an external electrical energy source. Therefore these batteries can be recharged by passing electric current and used again and again.

Anode : Lead packed with finely divided spongy lead.

Cathode : Lead packed with PbO_2.

Electrolyte : Aqueous solution of H_2SO_4.

At anode :

$Pb_{(s)} + SO^{2-}_{4(aq)} \longrightarrow PbSO_{4(s)} + 2e^-$

At cathode :

$PbO_{2(s)} + 4H^+_{(aq)} + SO^{2-}_{4(aq)} + 2e^- \longrightarrow PbSO_{4(s)} + 2H_2O_{(l)}$

Overall :

$Pb_{(s)} + PbO_{2(s)} + 2H_2SO_{4(aq)} \longrightarrow 2PbSO_{4(s)} + 2H_2O_{(l)}$

(b) $Zn_{(s)} + Ag_2O_{(s)} + H_2O_{(l)} \longrightarrow Zn^{2+}_{(aq)} + 2Ag_{(s)} + 2OH^-_{(aq)}$

Given : $E^\circ_{Ag^+/Ag} = +0.80$ V

$E^\circ_{Zn^{2+}/Zn} = -0.76$ V

$E^\circ_{cell} = E^\circ_{cathode} - E^\circ_{anode}$

$= 0.80 - (-0.76) = 1.56$ V

$\Delta G^\circ = -nFE^\circ = -2 \times 96500 \times 1.56$

$= -301080 = -301.08\ kJ\ mol^{-1}$

16. (a) Molar conductivity is the conductivity of all ions produced by ionisation of 1 g-mole of an electrolyte when present in V mL of solution. It is denoted by Λ_m.

$\Lambda_m = \kappa \times V$

V = volume in mL containing 1 g-mole of the electrolyte.

$$\Lambda_m = \kappa \times \frac{1000}{C}$$

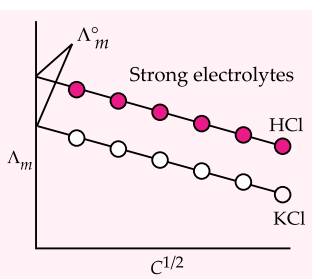
C = concentration of solution in g-mole/L

Variation of molar conductivity with concentration may be given by the expression

$\Lambda_m = \Lambda^\circ_m - AC^{1/2}$

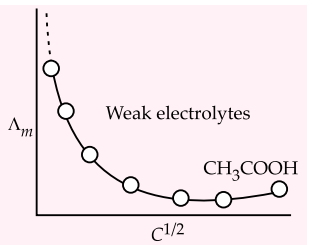
where A is a constant and Λ° is called molar conductivity at infinite dilution.

In case of strong electrolytes, molar conductivity increases slowly with dilution and there is a tendency for molar conductivity to approach a certain limiting value when the concentration approaches zero, *i.e.*, when the dilution is infinite.



The weak electrolytes dissociate to a much lesser extent as compared to strong electrolytes. Therefore, the molar conductivity is low as compared to that of strong electrolytes.

However, the variation of Λ_m with $C^{1/2}$ is very large and so much so that we cannot obtain molar conductance at infinite dilution (Λ°_m) by extrapolation of the Λ_m versus $C^{1/2}$ plots.



(b) Conductivity, $\kappa = 0.146 \times 10^{-3}$ S cm^{-1}

Resistance, R = 1500 ohm

$$\text{Cell constant} = \frac{\text{Conductivity } (\kappa)}{\text{Conductance } (G)}$$

$$= \text{Conductivity } (\kappa) \times \text{Resistance } (R)$$

$$\therefore \quad \text{Cell constant} = 0.146 \times 10^{-3} \times 1500$$

$$= 0.219 \text{ cm}^{-1}$$

17. Given : diameter = 1 cm, length = 50 cm

$R = 5.5 \times 10^3$ ohm, M = 0.05 M

ρ = ? κ = ? Λ_m = ?

$$\text{Area of the column, } a = \pi r^2 = 3.14 \times \left(\frac{1}{2} \text{ cm}\right)^2$$

$$= \frac{3.14}{4} \text{ cm}^2$$

$$\text{Resistivity, } \rho = R \cdot \frac{a}{l}$$

$$= 5.5 \times 10^3 \text{ ohm} \times \frac{3.14 \text{ cm}^2}{4 \times 50 \text{ cm}}$$

$$= 86.35 \text{ ohm cm}$$

$$\text{Conductivity, } \kappa = \frac{1}{\rho}$$

$$= \frac{1}{86.35} = 1.158 \times 10^{-2} \text{ ohm}^{-1} \text{ cm}^{-1}$$

$$\text{Molar conductivity, } \Lambda_m = \kappa \cdot \frac{10^3}{M}$$

$$= 1.158 \times 10^{-2} \text{ ohm}^{-1} \text{ cm}^{-1} \times \frac{10^3}{5 \times 10^{-2}}$$

$$= 231.6 \text{ ohm}^{-1} \text{ cm}^2 \text{ mol}^{-1}$$

18. At anode : $[Al_{(s)} \rightarrow Al^{3+}_{(aq)} + 3e^-] \times 2$

At cathode: $[Ni^{2+}_{(aq)} + 2e^- \rightarrow Ni_{(s)}] \times 3$

Cell reaction : $2Al_{(s)} + 3Ni^{2+}_{(aq)} \rightarrow 2Al^{3+}_{(aq)} + 3Ni_{(s)}$

Applying Nernst equation to the above cell reaction

$$E_{cell} = E^\circ_{cell} - \frac{0.0591}{6} \log \frac{[Al^{3+}]^2}{[Ni^{2+}]^3}$$

Given, $E_{cell} = E^\circ_{Ni^{2+}/Ni} - E^\circ_{Al^{3+}/Al}$

$= -0.25 \text{ V} - (-1.66 \text{ V}) = 1.41 \text{ V}$,

$[Al^{3+}] = 1 \times 10^{-3}$ M, $[Ni^{2+}] = 0.5$ M

$$\therefore \quad E_{cell} = 1.41 \text{ V} - \frac{0.0591}{6} \log \frac{(10^{-3})^2}{(0.5)^3}$$

$$= 1.41 \text{ V} - \frac{0.0591}{6} \log (8 \times 10^{-6})$$

$$= 1.41 \text{V} - \frac{0.0591}{6} (-5.09)$$

$$= 1.41 \text{V} + 0.050 \text{ V} = 1.46 \text{ V}$$

19. The given reaction is

$$SO_2Cl_{2(g)} \longrightarrow SO_{2(g)} + Cl_{2(g)}$$

At $t = 0$	0.4 atm	0	0
At time t	$(0.4 - x)$ atm	x atm	x atm

Total pressure at time t will be

$$P_T = (0.4 - x) + x + x$$

$$= 0.4 + x$$

$$x = (P_T - 0.4)$$

Pressure of SO_2Cl_2 at time t will be

$$p_{SO_2Cl_2} = 0.4 - x$$

$$= 0.4 - (P_T - 0.4)$$

$$= 0.8 - P_T$$

At time (t = 100 s), P_T = 0.7 atm

$$\therefore \quad p_{SO_2Cl_2} = 0.8 - 0.7 = 0.1 \text{ atm}$$

According to first order kinetic equation

$$k = \frac{2.303}{t} \log_{10} \frac{p_{SO_2Cl_2} \text{ (initial)}}{p_{SO_2Cl_2} \text{ (after reaction)}}$$

$$= \frac{2.303}{100} \log \left(\frac{0.4}{0.1}\right)$$

$$= \frac{2.303}{100} \times 0.6021 = 1.3 \times 10^{-2} \text{ s}^{-1}$$

20. (a) (i) Reaction is first order in A and second order in B, hence differential rate equation is

$$\frac{dx}{dt} = k[A][B]^2$$

(ii) Rate = $k[A][B]^2$
If $[A]$ is tripled,
Rate = $k[3A][B]^2$ *i.e.,* rate increases 3 times.

(iii) If both $[A]$ and $[B]$ are doubled,
Rate = $k[2A]\ [2B]^2 = 8k[A][B]^2$
i.e., Rate of reaction increases 8 times.

(b) 30% decomposition means that
x = 30% of R_0 or, $R = R_0 - 0.3R_0 = 0.7R_0$
For reaction of first order,

$$k = \frac{2.303}{t}\log\frac{[R]_0}{[R]} = \frac{2.303}{40}\log\frac{R_0}{0.7R_0}$$

$$= \frac{2.303}{40}\log\frac{10}{7}\ \text{min}^{-1} = \frac{2.303}{40}\log 1.428\ \text{min}^{-1}$$

$$= \frac{2.303}{40}\times 0.1548\ \text{min}^{-1} = 8.913\times10^{-3}\ \text{min}^{-1}$$

For a first order reaction,

$$t_{1/2} = \frac{0.693}{k} = \frac{0.693}{8.913\times10^{-3}\ \text{min}^{-1}}$$

$$= 77.7\ \text{min}$$

21. (a) For first order reaction, $t = \frac{2.303}{k}\log\frac{R_0}{R_t}$

For 99% completion of reaction
$t = t_{0.99}$, $R_0 = 1$, $R_t = (1 - 0.99) = 0.01 = 10^{-2}$

$$t_{0.99} = \frac{2.303}{k}\log\frac{1}{10^{-2}} = \frac{2.303}{k}\log 10^2$$

$$= \frac{2.303}{k}\times 2 \quad ...(i)$$

For 90% completion of reaction
$t = t_{0.90}$, $R_0 = 1$, $R_t = (1 - 0.9) = 0.1 = 10^{-1}$

$$t_{0.90} = \frac{2.303}{k}\log\frac{1}{10^{-1}} = \frac{2.303}{k}\log 10$$

$$= \frac{2.303}{k} \quad ...(ii)$$

Comparing equation (i) and (ii)

$$t_{0.99} = 2 \times t_{0.90}$$

(b) $\log k = \log A - \frac{E_a}{2.303\,RT}$

Plot of $\log k$ *vs* $\frac{1}{T}$ gives a straight line with slope equal to $\frac{-E_a}{2.303\,R}$.

$$\therefore \quad \frac{-E_a}{2.303\,R} = -4250$$

$$E_a = 4250 \times 2.303 \times R$$

$$E_a = 4250 \times 2.303 \times 8.314$$

$$= 81375.35\ \text{J mol}^{-1}$$

$$= 81.375\ \text{kJ mol}^{-1}$$

22. Since the rate of a reaction quadruples when the temperature changes from 293 K to 313 K

$$\therefore \quad k_2 = 4k_1$$

$T_1 = 293$ K and $T_2 = 313$ K

According to Arrhenius equation

$$\log\frac{k_2}{k_1} = \frac{E_a}{2.303R}\left[\frac{T_2 - T_1}{T_1T_2}\right]$$

Putting the values

$$\log\frac{4k_1}{k_1} = \frac{E_a}{2.303 \times 8.314\ \text{J K}^{-1}\ \text{mol}^{-1}}\left[\frac{(313 - 293)\,\text{K}}{293\,\text{K} \times 313\ \text{K}}\right]$$

$$0.6021 = \frac{E_a \times 20\ \text{K}}{2.303 \times 8.314\ \text{J K}^{-1}\ \text{mol}^{-1} \times 293\ \text{K} \times 313\ \text{K}}$$

$$\therefore\ E_a = \frac{0.6021 \times 2.303 \times 8.314 \times 293 \times 313}{20}\ \text{J mol}^{-1}$$

$$= 52863.3\ \text{J mol}^{-1} = 52.86\ \text{kJ mol}^{-1}$$

23. (a) Rate law = $k[\text{NO}]^x\ [\text{Cl}_2]^y$

From exp. I, $0.60 = k(0.15)^x\ (0.15)^y$ ... (i)

From exp. II, $1.20 = k(0.15)^x\ (0.30)^y$ ... (ii)

From exp. III, $2.40 = k(0.30)^x\ (0.15)^y$... (iii)

Dividing eqn. (ii) by eqn. (i)

$$2 = \frac{k(0.15)^x(0.30)^y}{k(0.15)^x(0.15)^y} \Rightarrow 2 = (2)^y$$

or $y = 1$

Dividing eqn. (iii) by eqn. (i)

$$4 = \frac{k(0.30)^x(0.15)^y}{k(0.15)^x(0.15)^y} \Rightarrow 4 = (2)^x$$

or $x = 2$

Thus rate law = $k[\text{NO}]^2\ [\text{Cl}_2]$

(b) From eqn. (i),

$0.60 = k(0.15)^2\ (0.15)^1$

$$\Rightarrow \quad k = \frac{0.60}{0.15\times0.15\times0.15}$$

$$= 177.77\ \text{mol}^{-2}\ \text{L}^2\ \text{min}^{-1}$$

Units of $k = (\text{mol L}^{-1})^{1-n}\ \text{min}^{-1}$

n = overall order of reaction = 3

$k = \text{mol}^{-2}\ \text{L}^2\ \text{min}^{-1}$

(c) Rate = $k[NO]^2\,[Cl_2]$
$= 177.77 \times (0.25)^2 \times 0.25$
$= 2.77 \text{ mol } L^{-1} \text{ min}^{-1}$

24. (a) $\frac{x}{m} = kP^{1/n} (n > 1)$

$\log \frac{x}{m} = \log k + \frac{1}{n} \log P$

where $\frac{x}{m}$ is the mass of gas adsorbed per gram of the adsorbent and P is pressure of gas.

(b) Lyophilic sols are quite stable and cannot be easily precipitated.

(c) Associated colloid : Soap
Multimolecular colloid : Gold sol

25. Emulsions are colloidal systems in which both the dispersed phase and the dispersion medium are liquids. Types of emulsions :
- oil in water type *e.g.* milk.
- water in oil type *e.g.* butter.

26. (i) Multimolecular colloids : When the particles of substance which constitute dispersed phase are of molecular dimensions but when brought in colloidal state, a large number of such atoms or molecules group together into larger aggregates of colloidal size (1-1000 nm). These are called multimolecular colloids. *e.g.* gold sol.

(ii) Lyophobic sols : The colloids in which particles of the dispersed phase have no or very little affinity for dispersion medium are called lyophobic sols. These are irreversible in nature and need stabilising agents for their preservation. *e.g.*, As_2S_3 solution.

(iii) Emulsions : A colloidal dispersion of two immiscible liquids is called an emulsion.
(a) Water in oil type emulsion : When water is dispersed phase and oil is dispersion medium *e.g.*, butter, cod liver oil.
(b) Oil in water type emulsion : When oil is dispersed phase and water is dispersion medium *e.g.*, milk.

27. (i) Associated colloids (micelles) : Those colloids which behave as normal strong electrolytes at low concentration but show colloidal properties at higher concentration due to formation of aggregated particles of colloidal dimension. *e.g.* soaps and detergents.

(ii) Lyophilic sols : The colloidal sol in which the particles of the dispersed phase have a strong affinity for the dispersion medium are called lyophilic sols.
These colloidal sols, even if precipitated, change back to the colloid form simply by adding dispersion medium. So lyophilic sols are reversible in nature *e.g.*, glue, starch, rubber, etc.

(iii) Adsorption : The phenomenon of attracting and retaining the molecules of a substance on the surface of a liquid or a solid resulting into a higher concentration of the molecules on the surface is called adsorption. *e.g.* painting of a wooden article.

28. (i) Aerosol : Colloid of a liquid in a gas is called aerosol *e.g.* fog, sprays etc.

(ii) Emulsion : Emulsions are colloidal systems in which both the dispersed phase and the dispersion medium are liquids. Types of emulsions :
- oil in water type *e.g.* milk.
- water in oil type *e.g.* butter.

(iii) Micelle : Aggregated particles of associated colloids at high concentration are called micelles. *e.g.* soaps.

29.

Physical adsorption	Chemical adsorption
1. Forces of attraction between adsorbent and adsorbate are weak van der Waal's forces.	Forces between adsorbent and adsorbate are strong chemical bonds.
2. Heat of adsorption is low (5-10 kcal mol^{-1}).	Heat of adsorption is high (20-100 kcal mol^{-1}).
3. It is temporary and reversible.	It is permanent and irreversible.

CHEMISTRY MUSING

SOLUTION SET 18

1. (a) : Moles of NaOH consumed to neutralize $H_2SO_4 = 3$

Moles of H_2SO_4 present in the sample = 1.5

Weight of H_2SO_4 in sample = $1.5 \times 98 = 147$ g

$$\% \text{ purity} = \frac{147}{210} \times 100 = 70\ \%$$

2. (d)

3. (c) : H^- and CH_3^- are strong bases thus, poor leaving groups.

4. (a) : Iron oxide = 0.5434 g

Oxygen lost as H_2O = 0.1210 g

Iron = 0.5434 – 0.1210 = 0.4224 g

Element	Amount	% weight	No. of moles	Ratio
Iron	0.4224	77.73	1.39	1
Oxygen	0.1210	22.26	1.39	1

Thus, formula of the iron oxide is FeO.

5. (a) : $CH_3N{\equiv}C + 2H_2O \xrightarrow{\text{dil. HCl}} CH_3NH_2 + HCOOH$ (Formic acid)

$CH_3{-}N{\equiv}C + 4[H] \xrightarrow{\text{Ni or Pt}} CH_3NHCH_3$ (Dimethylamine)

Addition reactions,

$CH_3NC + Cl_2 \longrightarrow CH_3NCCl_2$

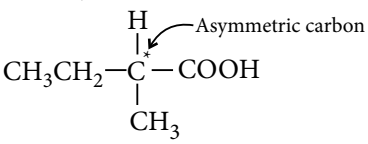
$CH_3NC + S \longrightarrow CH_3NCS$

6. (b) : (i) (*A*) $C_5H_8O_2$ liberates CO_2 with $NaHCO_3$ so, (*A*) is acid, *i.e.*, (*A*) is C_4H_7COOH.

(ii) (*A*) seems to be unsaturated acid and thus, shows geometrical isomerism.

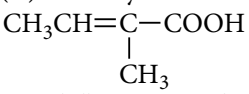
(iii) $\underset{(A)}{C_4H_7COOH} \xrightarrow{H_2} \underset{(B)}{C_5H_{10}O_2}$;

Since, (*B*) is optically active and thus, acid (*B*) may be



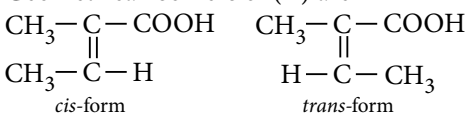
2-Methylbutanoic acid

(iv) Since, (*B*) is formed by hydrogenation of acid (*A*) having geometrical isomers, thus, (*A*) can only be



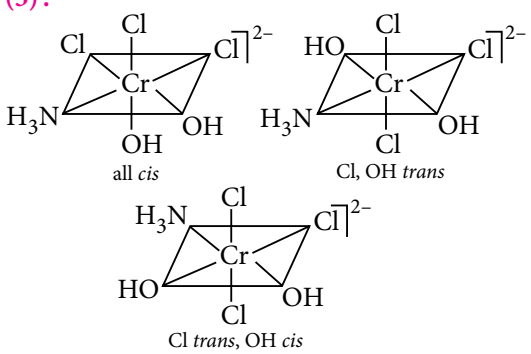
2-Methylbut-2-enoic acid

Geometrical isomers of (*A*) are



7. (d) **8. (c)**

9. (3) :



10. (4) : Rate constant at 400 K = k

$$\text{Rate constant at 410 K} = k + \left[k \times \frac{8}{100}\right] = 1.08\,k$$

$$\text{Thus, } 2.303 \log \frac{k_2}{k_1} = \frac{E_{a,f}}{R} \frac{[T_2 - T_1]}{T_2\,T_1}$$

$$2.303 \log \frac{1.08\,k}{k} = \frac{E_{a,f}}{2} \left[\frac{410 - 400}{410 \times 400}\right]$$

$\therefore \quad E_{a,f} = 2524.77$ cal

Now, equilibrium constant at 400 K = K'

$$\text{Eqm. constant at 410 K} = K' + \frac{3}{100} K' = 1.03\,K'$$

$$\text{Using, } 2.303 \log \frac{K_2}{K_1} = \frac{\Delta H^\circ}{R} \left[\frac{T_2 - T_1}{T_2\,T_1}\right]$$

$$2.303 \log \frac{1.03\,K'}{K'} = \frac{\Delta H^\circ}{2} \left[\frac{410 - 400}{410 \times 400}\right]$$

$\therefore \quad \Delta H^\circ = 969.70$ cal

$\Delta H^\circ = E_{a,f} - E_{a,b} \Rightarrow 969.70 = 2524.77 - E_{a,b}$

$\Rightarrow \quad E_{a,b} = 1555.07$ cal

$E_{a,f} + E_{a,b} = 2524.77 + 1555.07$

$= 4079.84$ cal or 4.07×10^3 cal

YOU ASKED WE ANSWERED

Do you have a question that you just can't get answered?

Use the vast expertise of our mtg team to get to the bottom of the question. From the serious to the silly, the controversial to the trivial, the team will tackle the questions, easy and tough.

The best questions and their solutions will be printed in this column each month.

Q1. Why burning Mg continues to burn in NO, but burning sulphur is extinguished?

–Pankaj Mishra, Mughalsarai, Chandauli, U.P.

Ans. Magnesium being a metal acts as a strong reducing agent with each atom of Mg losing its two outermost electrons to form Mg^{2+} ions. Hence, it reduces nitric oxide (NO) to Mg_3N_2.

$$5Mg + 2NO \longrightarrow 2MgO + Mg_3N_2$$

Heat evolved during burning of Mg is enough to decompose NO to N_2 and O_2. O_2 thus produced keeps Mg burning.

On the other hand, sulphur, being a non-metal acts as an oxidising agent. It does not conduct heat and electricity because unlike metals, it does not have free electrons. In contrast to Mg, the heat produced during burning of sulphur is not sufficient to decompose NO to N_2 and O_2. As a result, sulphur stops burning in NO.

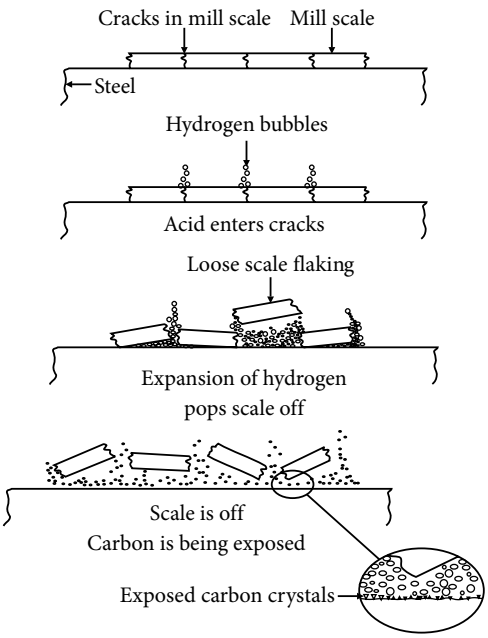
Q2. How can strong acids like conc. H_2SO_4 help clean the metal surfaces?

–G.S. Sudarshan, Mysore, Karnataka

Ans. Surfaces of metal equipments are cleaned from time to time to prevent damage and maintain their efficiency. For this, both acids and alkalis can be used. The choice of the type of acid and additives used, depends on the substrate, its nature and extent of the contamination. In general, strong acids such as hydrochloric acid (HCl), nitric acid (HNO_3), sulphuric acid (H_2SO_4) and phosphoric acid (H_3PO_4) are unsuitable for use to clean light metals such as aluminium, zinc, copper, nickel and are used for industrial cleaning.

"*Pickling*", is a metal cleaning process in which a strong inorganic acid (typically conc. HCl or H_2SO_4) is used at about 80°C, to strip the surface of dirt, oil, rust and scale. *e.g.*, if a steel surface covered with mill scale is immersed in conc. H_2SO_4 solution, the following steps occur :

1. Acid dissolves the surface iron (through the cracks in the mill scale), forming hydrogen bubbles.
2. Expansion of the hydrogen behind the mill scale loosens the mill scale.
3. Heat released during the reaction leads to rise in temperature.
4. As more and more acid combines with the iron, the free acid in the solution gets depleted.



5. The acid combining with the iron (in the form of rust) forms ferrous sulphate and flakes slowly settle at the bottom.
6. After the scale is removed, the steel continues to dissolve at a fast rate, causing a continuous formation of hydrogen.

$$\underset{\text{Iron}}{Fe} + \underset{\text{Acid}}{2H^+} \longrightarrow \underset{\text{Ferrous ion}}{Fe^{2+}} + H_{2(g)}$$

7. The surface of the steel is now free of, impurities and thus, looks like a new pure steel.

ADVANCED CHEMISTRY BLOC

(NUCLEAR CHEMISTRY)

Mukul C. Ray, Odisha

Concept of Matter and Antimatter

Energy is the most fundamental entity of the universe. Everything in the universe, excluding space, is energy in three different forms: energy, matter and antimatter. Sometimes books use the term "substance" which refers collectively to matter, antimatter and energy. Thus energy, matter and antimatter are defined as different forms of the same thing, substance.

In addition to the existing knowledge about matter, fundamental particles are also considered as matter. Although there are many fundamental particles, most of them have extremely short life times before they decay. The only stable fundamental particles are electrons and quarks. Quarks combine to form protons and neutrons. The electrons, protons and neutrons then combine to produce more complex matter objects such as atoms, molecules, liquids, gases, chairs, animals, plants, stars, etc.

But what is antimatter? It was in 1930, while developing equations for the motion of electrons in magnetic fields; Paul Dirac could predict theoretically the existence of antimatter particles. Today it is known that every fundamental matter particle has a corresponding antimatter particle. An antimatter particle and its partner particle usually annihilate each other when they meet, and the result is a release of free energy.

Humans usually do not encounter antimatter particles, because free antimatter particles are practically non-existent in the universe. Whenever antimatter particles occur, either naturally or in experiments, they quickly find a matter partner with which they combine and annihilate. In modern medical diagnostic process called PET (Positron Emission Tomography), the instrument creates positrons (antimatter of electron) and uses them to image human tissues, bones, teeth, cartilages, etc.

Note that few fundamental particles like photon do not have antiparticles. However, when two photons meet they annihilate leaving behind other particles. That is why photon can be considered to be its own antiparticle.

Stability of Nucleus

There are a number of theories to explain nuclear stability; one of them is the *n*/*p* ratio. This one is a powerful concept. It tries to tell only one thing; whenever the neutron-proton ratio is unstable the nucleus undergoes radioactive decay to make the ratio stable.

When *n*/*p* ratio is high :

- Nucleus emits a beta particle. One of the neutrons from the nucleus disintegrates to lower the *n*/*p* value as:

  $_0n^1 \rightarrow {}_1H^1 + {}_{-1}e^0$

  The beta particle leaves the nucleus and positive charge of the nucleus increases by one unit. Now the product picks an electron from the atmosphere to become neutral. C^{14}, H^3 and Al^{29} are beta emitters.
- Alternatively, neutron emission may take place but this is rare and is possible only with highly energetic nuclei.

When *n*/*p* ratio is low :

- Positron emission is one way to raise the *n*/*p* ratio. C^{11} and Ne^{19} emit positrons.
- Another way is to capture an electron from *K*-shell by a process known as *K*-electron capture. One of the protons of the nucleus now becomes a neutron. But this is a rare phenomenon and takes place only when the nucleus has insufficient energy for positron emission. Be^{7} and K^{40} show *K*-capture.
- For heavier nucleus, alpha emission is another way to raise *n*/*p* ratio.
- Proton emission that requires high energy is rarely possible.

Besides this explanation of what could be the possible reason for radioactivity, the notable observations are:

- Only two stable isotopes (H^{1} and He^{3}) have more protons than neutrons.
- Beyond bismuth (atomic number 83, mass number 209), all isotopes are unstable and radioactive. There is apparently no nuclear "superglue" strong enough to hold heavier nuclei together.
- Isotope stability is associated with even atomic numbers and even atomic weights. Out of the stable isotopes, 148 have an even number of protons and neutrons, 53 have even number of protons and odd number of neutrons, and 48 have an odd number of protons and an even number of neutrons. Only five stable isotopes (H^{2}, Li^{6}, B^{10}, N^{14} and Ta^{180}) have odd number of both protons and neutrons.

Summary of Radiations

Gamma rays are emitted during alpha, beta, positron emission and *K*-capture. After these activities nucleus remains in high energy state and then it emits gamma rays.

Gamma rays penetrate very deep into matter. High energy gamma rays interact with atomic nuclei to eject a positron and an electron. Beta rays follow tortuous or winding or twisting path through matter and eject orbital electrons to cause ionization. Alpha particles cannot cross the epidermis and produce ion pairs during their short courses.

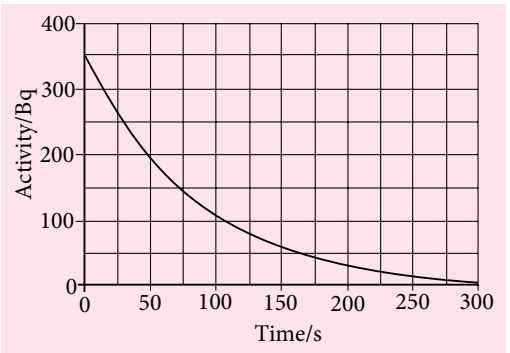
Rate of Radioactive Disintegration

Radioactive decay is a random process and the decay of an individual nucleus cannot be predicted. However, given a sample containing a large number of undecayed nuclei, then statistically the rate of decay is proportional to the number of undecayed nuclei.

There are only two factors that determine the rate of decay of a sample of radioactive material. They are:

- the radioactive isotope involved.
- the number of undecayed nuclei.

A decay curve as shown in the diagram is obtained and the shape of the curve is same for all the radioactive substances, but the activities and time scales depend on the size of the sample and its decay constant.



Also, it follows the equation :

$$\lambda = \frac{1}{t} \ln \frac{N_0}{N_t}$$

Besides the common concept of half-life, there is another concept called average life. Its theoretical meaning is

$$\text{Average life} = \frac{\text{Total life time of all the nuclei in a given sample}}{\text{Total number of nuclei in a given sample}}$$

Mathematically,

$$\text{Average life} = \frac{1}{\lambda}$$

where λ is the disintegration constant.

Radioactive Disintegration Series

The radioactive disintegration series are groups of radioactive nuclei that arise from the production in nucleosynthesis of long-lived alpha emitters. The "head" of each series decays to form a set of radioactive progeny that decays further by either alpha or beta emission. In alpha emission the mass number is reduced by 4 and in beta emission it remains unchanged.

This means, in principle, there are four possible series of radioactive nuclei.

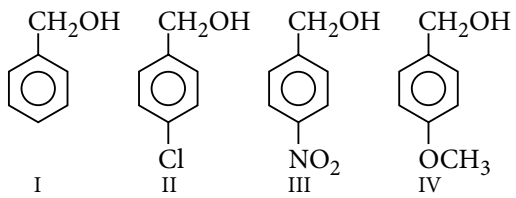
Name of series	Type of series	Parent element	Stable product	No. of decays
Thorium series	$4n$	Th^{232}	Pb^{208}	$\alpha = 6$, $\beta = 4$
Neptunium series	$4n + 1$	Pu^{241}	Bi^{209}	$\alpha = 8$, $\beta = 5$
Uranium series	$4n + 2$	U^{238}	Pb^{206}	$\alpha = 8$, $\beta = 6$
Actinium series	$4n + 3$	U^{235}	Pb^{207}	$\alpha = 7$, $\beta = 4$

The $4n + 1$ series starts from plutonium but is commonly known as Neptunium series as neptunium is the longest-lived member of the series. Similar is the name for the actinium series. Plutonium and neptunium are no more natural elements (thus $4n + 1$ series is known as artificial series) as their half-lives are too short as compared to the age of earth.

PRACTICE PROBLEMS 2Q15

Chemistry Olympiad

1. The correct sequence representing the basic character of the following alcohols is



(a) IV > I > II > III (b) II > III > IV > I
(c) IV > II > III > I (d) I > II > III > IV

2. The amount of $NaHCO_3$ in an antacid tablet is to be determined by dissolving the tablet in water and titrating the resulting solution with HCl.

Acid	K_a
H_2CO_3	2.5×10^{-4}
HCO_3^-	2.5×10^{-8}

Which indicator is the most appropriate for this titration?
(a) Methyl orange, $pK_{indicator} = 3.7$
(b) Bromothymol blue, $pK_{indicator} = 7.0$
(c) Phenolphthalein, $pK_{indicator} = 9.3$
(d) Alizarin yellow, $pK_{indicator} = 12.5$

3. A carbocation and a triplet carbene are respectively …… and …… in nature.
(a) paramagnetic, paramagnetic
(b) diamagnetic, paramagnetic
(c) diamagnetic, diamagnetic
(d) paramagnetic, diamagnetic

4. Calculate the fall in temperature of helium initially at 15°C, when it is suddenly expanded to 8 times its volume. (The ratio of specific heats $= \frac{5}{3}$)
(a) 210°C (b) – 216°C
(c) – 210°C (d) 216°C

5. Which of the following halides is not oxidised by MnO_2 ?
(a) F^- (b) Cl^-
(c) Br^- (d) I^-

6. After electrolysis of a sodium chloride solution with inert electrodes for a certain period of time, 600 mL of the 1 N solution was left which was found to be NaOH. During the same time 31.80 g of Cu was deposited in copper voltameter in series with the electrolytic cell. The % yield of NaOH obtained is (Atomic mass of Cu = 63.6)
(a) 72 % (b) 80 %
(c) 62 % (d) 60 %

7. An alkyl chloride produces a single alkene on reaction with sodium ethoxide and ethanol. The alkene further undergoes hydrogenation to yield 2-methylbutane. Identify the alkyl chloride amongst the following.
(a) $ClCH_2CH(CH_3)CH_2CH_3$
(b) $ClCH_2CH_2CH_2CH_2CH_3$
(c) $ClCH_2C(CH_3)_2CH_3$
(d) $CH_3C(Cl)(CH_3)CH_2CH_3$

8. A mineral (MX_2) is formed by two elements *M* and *X*. Atoms of the element *M* (as cations) make *ccp* and those of the element *X* (as anions) occupy the tetrahedral voids. The number of cations and anions per unit cell, the coordination number of cation and percentage of tetrahedral voids occupied are
(a) 8, 4, 8, 100 % (b) 8, 4, 8, 50 %
(c) 4, 8, 8, 50 % (d) 4, 8, 8, 100 %

9. Following statements regarding the periodic trends of chemical reactivity of the alkali metals and the halogens are given. Which of these statements gives the correct picture?

(a) Chemical reactivity increases with increase in atomic number down the group in both the alkali metals and halogens.
(b) In alkali metals, the reactivity increases but in the halogens it decreases with increase in atomic number down the group.
(c) The reactivity decreases in the alkali metals but increases in the halogens with increase in atomic number down the group.
(d) In both the alkali metals and the halogens the chemical reactivity decreases with increase in atomic number down the group.

10. 0.535 g ethanol and acetaldehyde mixtures when heated with Fehling's solution gave 1.2 g of red precipitate. What is the percentage of acetaldehyde in the mixture?
(a) 89.2 % (b) 68.9 %
(c) 62.8 % (d) 86.9 %

11. Which of the following esters cannot undergo intramolecular Claisen condensation?
(a) $CH_3CH_2CH_2CH_2COOC_2H_5$
(b) $C_6H_5COOC_2H_5$
(c) $C_6H_{11}CH_2COOC_2H_5$
(d) $C_6H_5CH_2COOC_2H_5$

12. In the Arrhenius equation for a certain reaction, the values of A and E_a (energy of activation) are 4×10^{13} s^{-1} and 98.6 kJ mol^{-1} respectively. If the reaction is of first order, at what temperature will its half life period be 10 minutes?
(a) 311.35 K (b) 301.35 K
(c) 310.35 K (d) 300.2 K

13. A metal M readily forms its sulphate MSO_4 which is water soluble. It forms its oxide MO which becomes inert on heating. It forms an insoluble hydroxide $M(OH)_2$ which is soluble in NaOH solution. Then M is
(a) Mg (b) Ba
(c) Ca (d) Be

14. Lactic acid on oxidation by alkaline potassium permanganate gives
(a) tartaric acid (b) pyruvic acid
(c) cinnamic acid (d) propionic acid.

15. Which of the following reactions will not produce chlorine gas?
(a) $K_2Cr_2O_7 + HCl \xrightarrow{\Delta}$
(b) $MnO_2 + HCl \xrightarrow{\Delta}$
(c) $KMnO_4 + HCl \xrightarrow{\Delta}$
(d) $K_2Cr_2O_7 + H_2SO_4(conc.) + NaCl \xrightarrow{\Delta}$

16. Pyridine has 6 bonding (π) and 2 non-bonding electrons, which statement is true regarding resonance in pyridine?
(a) All of these electrons are involved in resonance.
(b) 4 π and 2 non-bonding electrons are involved in resonance.
(c) Only 6 π electrons are involved in resonance.
(d) Any of the 6 electrons may get involved in resonance.

17. The following equilibrium is established when hydrogen chloride is dissolved in acetic acid.
$HCl + CH_3COOH \rightleftharpoons Cl^- + CH_3COOH_2^+$
The set that characterises the conjugate acid-base pairs is
(a) (HCl, CH_3COOH) and ($CH_3COOH_2^+$, Cl^-)
(b) (HCl, $CH_3COOH_2^+$) and (CH_3COOH, Cl^-)
(c) ($CH_3COOH_2^+$, HCl) and (Cl^-, CH_3COOH)
(d) (HCl, Cl^-) and ($CH_3COOH_2^+$, CH_3COOH)

18. Which of the following statements is not true?
(a) At room temperature, formyl chloride is present in the form of CO and HCl.
(b) Acetamide behaves as a weak base as well as a weak acid.
(c) Acetamide on reduction with $LiAlH_4$ gives ethylamine.
(d) None of these.

19. A Zn rod weighing 25 g was kept in 100 mL of 1 M $CuSO_4$ solution. After a certain time the molarity of Cu^{2+} in solution was 0.8 M. The molarity of SO_4^{2-} (At. wt. of Zn = 65.4)
(a) will increase by 10 M
(b) will decrease by 10 M
(c) will remain unchanged
(d) can't say.

20. The basic character of ethylamine, diethylamine and triethylamine in chlorobenzene is
(a) $C_2H_5NH_2 < (C_2H_5)_2NH < (C_2H_5)_3N$
(b) $C_2H_5NH_2 < (C_2H_5)_3N < (C_2H_5)_2NH$
(c) $(C_2H_5)_3N < (C_2H_5)_2NH < C_2H_5NH_2$
(d) $(C_2H_5)_3N < C_2H_5NH_2 < (C_2H_5)_2NH$

21. In the reaction:

$$3Br_2 + 6CO_3^{2-} + 3H_2O \longrightarrow 5Br^- + BrO_3^- + 6HCO_3^-$$

(a) Bromine is oxidised and carbonate is reduced.
(b) Bromine is both oxidised and reduced.
(c) Bromine is reduced and water is oxidised.
(d) Bromine is neither oxidised nor reduced.

22. Milk is an emulsion of fat dispersed in water. It is stabilized by :
(a) casein – a lyophilic colloidal sol
(b) casein – a lyophobic colloidal sol
(c) lactose – a lyophilic colloidal sol
(d) lactose – a lyophobic colloidal sol

23. Phenol is converted into bakelite by heating it with formaldehyde in presence of alkali or acid. Which statement is true regarding this reaction?
(a) The electrophile in both cases is $CH_2=\overset{+}{O}$
(b) The electrophile in both cases is $CH_2=\overset{+}{O}H$
(c) The electrophile is $CH_2=O$ in presence of alkali and $CH_2=\overset{+}{O}H$ in presence of acid.
(d) It is a nucleophilic substitution reaction.

24. What are the products *X*, *Y*, *Z* (aliphatic class)?

$$CO + H_2 \xrightarrow{Ni} X$$

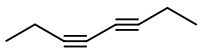
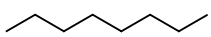
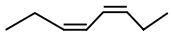
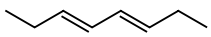
$$CO + H_2 \xrightarrow{Cu} Y$$

$$CO + H_2 \xrightarrow{ZnO + Cr_2O_3} Z$$

(a) CH_3OH in all cases.
(b) CH_3OH, HCHO, CH_4
(c) CH_4, HCHO, CH_3OH
(d) CH_4, CH_3OH, HCHO

25. In photography, sodium thiosulphate is used for
(a) softening very dark images
(b) making the latent image visible
(c) intensifying faint images
(d) dissolving residual silver bromide.

26. The energies of I, II and III energy levels of a certain atom are *E*, $\frac{4E}{3}$ and $2E$ respectively. A photon of wavelength λ is emitted during a transition from III to I. What will be the wavelength of emission for transition II to I?
(a) $\frac{\lambda}{2}$ (b) λ
(c) 2λ (d) 3λ

27.  $\xrightarrow{Na/liq.\ NH_3}$ *P*; *P* is
(a)  (b) 
(c)  (d) none of these.

28. Which of the following statements is correct?
(a) FeI_3 is stable in aqueous solution.
(b) An acidified solution of K_2CrO_4 gives yellow precipitate on mixing with lead acetate.
(c) The species $[CuCl_4]^{2-}$ exists but $[CuI_4]^{2-}$ does not.
(d) Both copper (I) and copper (II) salts are known in aqueous solution.

29. 8 g each of oxygen and hydrogen at 27°C will have the total kinetic energy in the ratio of
(a) 1 : 16 (b) 16 : 1
(c) 4 : 1 (d) 1 : 4

30. *P* and *Q* are two elements which form P_2Q_3 and PQ_2. If 0.15 mole of P_2Q_3 weighs 15.9 g and 0.15 mole of PQ_2 weighs 9.3 g, then the atomic weights of *P* and *Q* are respectively
(a) 36, 18 (b) 26, 18
(c) 18, 26 (d) none of these.

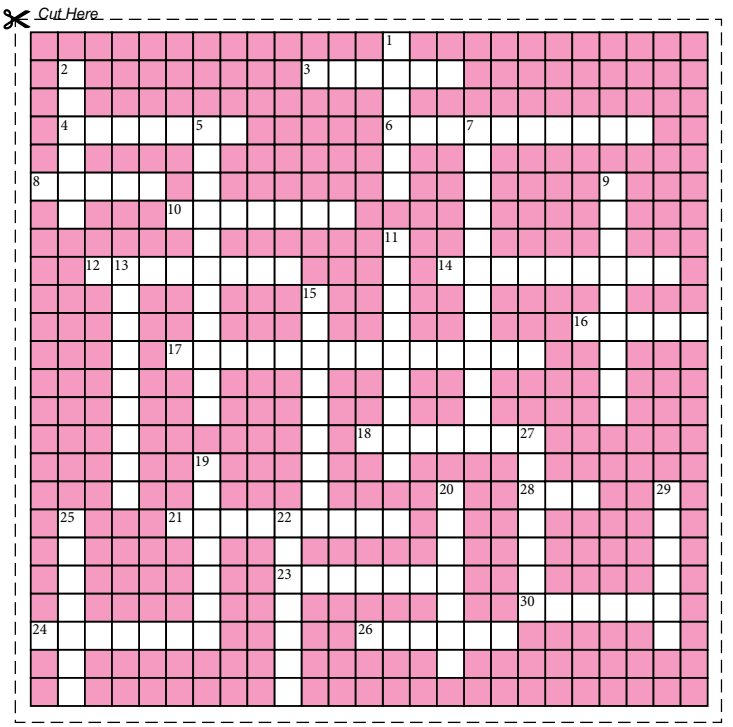
ANSWER KEYS

1. (a)	**2.** (a)	**3.** (b)	**4.** (d)	**5.** (a)
6. (d)	**7.** (a)	**8.** (d)	**9.** (b)	**10.** (b)
11. (b)	**12.** (a)	**13.** (d)	**14.** (b)	**15.** (d)
16. (c)	**17.** (d)	**18.** (d)	**19.** (c)	**20.** (a)
21. (b)	**22.** (a)	**23.** (c)	**24.** (c)	**25.** (c)
26. (d)	**27.** (c)	**28.** (c)	**29.** (a)	**30.** (b)

VIT University Chancellor Dr. G. Viswanathan met the Hon'ble Minister for Human Resource and Development, Mrs. Smriti Zubin Irani in New Delhi recently and honoured her on assuming as Union Minister.

CROSSWORD

Readers can send their answer with complete address by 15th of every month to win exciting prizes.
Winners' name with their valuable feedback will be published in next issue.



ACROSS

3. _____ II behaves like a liquid with gas like properties. (6)

4. Another name for crude Chile saltpetre which contains 0.02% iodine as sodium iodate. (7)

6. A mixture of calcium phosphate and calcium silicate. (10)

8. A polyester used in making bullet proof windows. (5)

10. Extractor used for separating organic compounds with a minimum amount of organic solvent. (7)

12. The process of removing layers of basic oxides from metal surfaces before electroplating. (8)

14. Fruit sugar. (9)

16. A radioactive element used in non surgical treatment of cancer and other malignant growths. (5)

17. The reaction used to introduce a formyl group into benzene ring. (14)

18. IUPAC name of grain alcohol. (7)

21. Source of Plaster of Paris. (9)

23. Element used in quartz thermostats for measuring high temperatures. (7)

24. Solvent used in Rast method for determining depression in melting point. (7)

26. Quantum of thermal energy. (6)

28. Dichloride of this element is used as a mordant in dyeing textiles and for increasing the weight of silk. (3)

30. A biological molecule that catalyses reactions in living things. (6)

DOWN

1. A vitamin neither soluble in water nor in fat. (6)

2. Process by which acetaldehyde is manufactured from ethylene. (6)

5. Polysaccharides consisting of only one type of monosaccharide subunits. (11)

7. Amorphous boron of low purity. (12)

9. The point of temperature inversion between mesosphere and thermosphere. (9)

11. Hardest variety of iron. (9)

13. Molecules containing same number of atoms and electrons. (9)

15. Basic salt of copper used as a green pigment in paints. (9)

19. Chemical name of brimstone. (7)

20. Metastable phase of carbon under normal conditions. (7)

22. Silver sol used as eye lotion. (7)

25. A stable complex of a metal with one or more polydentate ligands. (7)

27. The three-dimensional arrangement of atoms in a crystal. (7)

29. A solution that resists changes in pH if an acid or base is added. (6)